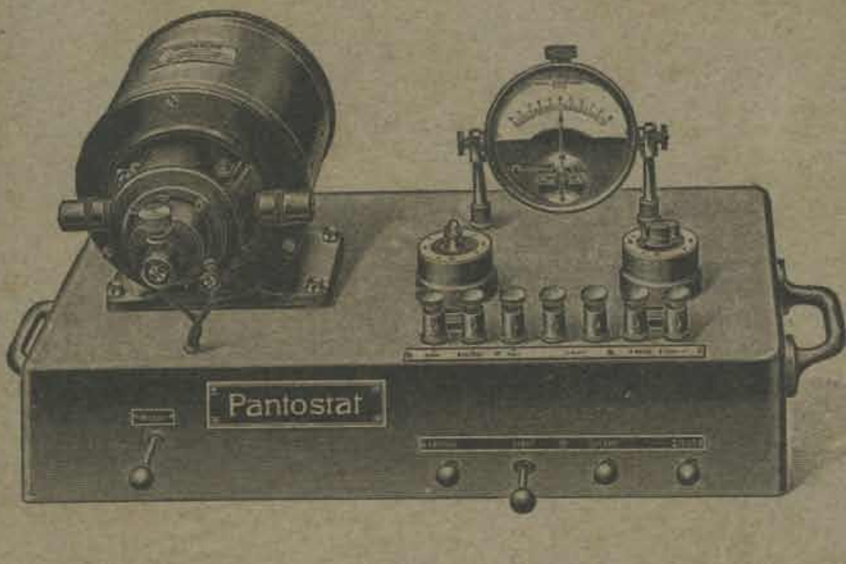
Electro-Medical Instruments and their Management . .

AND

Illustrated Price List of Electro-Medical Apparatus.



BY

SCHALL & SON.
Managing Director: W. E. SCHALL, B.Sc. Lond.

71 and 75, New Cavendish Street, LONDON, W.

Telegraphic Address: "*SCHALL, WESDOLONDON.*"
Telephone: *MAYFAIR, 1212.*

FIFTEENTH EDITION. JULY, 1913.

Bristol:
JOHN WRIGHT & SONS LTD., STONE BRIDGE.

PRICE 2/6.

ELECTRO-MEDICAL INSTRUMENTS
AND THEIR MANAGEMENT.

Electro-Medical Instruments and Their Management.

AND

Illustrated Price List of Electro-Medical Apparatus.

BY

SCHALL & SON.
71 and 75, New Cavendish Street, LONDON, W.

Telegraphic Address: "SCHALL, WESDOLONDON."
Telephone: MAYFAIR, 1212.

FIFTEENTH EDITION. JULY, 1913.

Bristol:
JOHN WRIGHT & SONS LTD., STONE BRIDGE.

PRICE 2/6.

JOHN WRIGHT AND SONS LTD.,
PRINTERS, BRISTOL.

CONTENTS OF "ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT."

CONTENTS OF THE PRICE LIST.

PREFACE.

The following pages explain as simply as possible the physical laws which are of importance in using Electricity for Medical and Surgical purposes. They describe the necessary apparatus and their construction; they give a few practical hints about the apparatus best suited under special circumstances; they show how faults may be avoided, or, at any rate, how they may be detected and rectified.

Should the reader who lacks time to study larger works on Electricity find the following pages a help in making his electrical instruments familiar to him, thus facilitating their management, this little pamphlet will not have been written in vain.

1892. K. SCHALL.

The pamphlet, "Electro-Medical Instruments and their Management," was published for the first time about twenty years ago. Since that time many Medical Men have assured me that it has been a help to them, and this encourages me not only to republish, but also to enlarge it considerably, hoping that the new chapters likewise may be found useful.

The part about X Rays has been entirely rewritten, to bring it up to date.

June, 1913. W. E. SCHALL, B.Sc. Lond.

ELECTRO-MEDICAL INSTRUMENTS AND THEIR MANAGEMENT.

ELECTRICITY is the result of some kind of motion, like heat, light, magnetism, etc. ; it is closely related to these forces and can be easily converted into them.

We possess many means and ways of producing it, such as friction, chemical action, induction, mechanical power, etc. All these methods are used in applying electricity for medical purposes ; but before explaining them, it will be necessary to define a few general expressions.

Positive and Negative.—If we rub a glass bar or a stick of sealing-wax with a dry cloth or fur, and apply the knuckle to the rubbed place, a small spark appears. The friction has electrified the sticks, and the consequence thereof is that they attract light things, such as pieces of paper, electrify these as well, but repel them immediately after having touched them. A glass bar repels a piece of paper after having electrified it ; but a stick of sealing-wax, after having been rubbed, attracts the same paper strongly. This shows that the electricity in the glass bar is not the same as the electricity in the stick of wax. It is the custom to call the kind of electricity produced through rubbing a glass bar *positive* electricity, and the electricity produced by rubbing a stick of wax or india-rubber, *negative* electricity. The above experiment shows that two bodies charged with the same kind of electricity repel each other, and that bodies charged with different kinds of electricity attract each other.

Normal Condition.—It is a mistake to imagine that the friction has charmed some new strange power into the sticks. It will be more correct to suppose that, in their normal (that is to say unrubbed) condition, the sticks contained negative and positive electricity in equal quantities, and as long as this was the case we could not discern the presence of the power at all. The friction, however, disturbed the normal condition by separating the two kinds of electricity contained in those bodies, and under these conditions only can we detect the presence of electricity.

Conductors and Insulators.—The separated kinds of electricity can be united again by means of a conductor. After rubbing a glass bar, or a stick of wax, we find that it has become electrified in the rubbed places only, and remains non-electric where it was not rubbed. Obviously therefore electricity cannot spread equally over glass or wax, but remains localised. Substances which do not conduct electricity, such as glass, oil, *pure* water, air, paraffin-wax, etc., are called non-conductors or insulators. Other substances which

allow electricity to pass freely, such as all metals, carbon, some minerals, etc., are called conductors. Between conductors and non-conductors there is a third class of materials, which do not conduct electricity nearly as well as metals do, but which still conduct it to a certain extent; such as acids, salt and alkali solutions, etc. Such fluids are called half-conductors. Now to this class belongs the human body.

It is of the greatest importance that there are bodies which conduct, and others which do not conduct, electricity, for we are thus enabled to direct the electricity exactly to the spot where we desire its action, and to send it along metal wires which are supported by insulators, over any distance we like.

For a long time friction was the only means known to electrify bodies; but about a hundred years ago, Volta and Galvani discovered another and far more convenient method to produce electricity, *i.e.*, the simple contact of two different metals, and chemical action. They thereby gave the first impulse to the wonderful development of electricity which we have witnessed in our day. The electricity produced in this way has been called galvanic electricity, in honour of one of its discoverers.

GALVANIC ELECTRICITY.

Electro-motive Force.—If we immerse a piece of metal in some fluid which has the power of acting chemically on the metal, the two kinds of electricity are separated too. The power which disturbs the normal condition, and separates the positive from the negative electricity, is called *electro-motive force*. The E.M.F. is in some proportion to the intensity of the chemical action, but is *independent of the size or shape of the metal.*

If we immerse zinc in diluted sulphuric acid, the zinc becomes negatively, the sulphuric acid a little positively, electric. Platinum immersed in sulphuric acid gets positively electric, and the acid becomes negative. This shows that different metals react differently with one and the same liquid, and they can be classified in such an order that, in contact with a liquid, always the preceding metal gets negative compared with those that follow. In diluted sulphuric acid, for instance, the most important metals follow one another as follows: Zinc, lead, copper, silver, platinum, carbon.

By immersing at the same time two different metals, the one of which gets negatively, and the other positively, electric, we increase the tension, for in this case we have two E.M.F.'s instead of one. On the exciting liquid much depends too; zinc and carbon, for instance, have twice as high an E.M.F. if dipped in chromic acid than when dipped in sulphuric acid only. Such an arrangement, i.e., two metals, or a carbon and a metal, in an exciting fluid, is called a galvanic element or cell.

Arrangement of Cells.—No single cell possesses an E.M.F. higher than two units, if we take that of the Daniell cell as one unit. A much larger E.M.F. is often needed, and we can obtain it by connecting several cells, so that the zinc of the first cell is connected with the carbon of the second, the zinc of the second with the carbon of the third, etc. In this way we add the

E.M.F.'s of the single cells together, and if, for instance, forty Leclanché cells are connected like this, the E.M.F. between the two end poles (i.e., the first carbon and the fortieth zinc) will be forty times as high as that of a single Leclanché cell. To connect the cells in this manner is called connection "in series." There are other ways of connecting elements, but as these are of importance for cautery only, we shall explain them under cautery.

Current.—As soon as the two metals are connected by a conductor or half-conductor, the two separated kinds of electricity are able to reunite again. While discharging, the electricity accumulated at the poles gets less, but it is replaced immediately by the E.M.F., so that the discharge goes on as long as the electrifying cause (in this case the chemical action) exists, or till the circuit gets broken. There exists, then, in the circuit a *continuous current*, which is generally supposed to start from the positive pole, and to pass through the conductor to the negative pole, and inside the cell from the negative metal through the exciting liquid to the positive metal, thereby forming a complete circuit.

The larger a cell and its store of chemicals is, the longer will it be able therefore to maintain a current, and the constancy of an element, i.e., the length of time for which an even strength of current can be got out of it, is in direct proportion to its size.

If we call the metal *positive* from which the current starts into the conductor; the copper, for instance, is *positive* as far as it projects above the liquid, but is *negative* as far as it is covered by the liquid, and *vice versa* with the zinc.

Resistance.—The free passage of the current depends on the nature of the conductor through which the current has to pass. We have already mentioned that the conducting capacity of various bodies varies widely. Metals are the best conductors, but even they differ much: one yard of copper wire allows ten times as much electricity to pass as one yard of German silver wire. It would be more correct to say that German silver has ten times the resistance of copper. The resistance increases with the length, ten yards of wire having twice as much resistance as five yards of the same wire. If, however, the diameter of the conductor increases, the resistance decreases accordingly. The resistance of the human body is ten times less if we apply electrodes ten inches square than if we apply electrodes one inch square only.

Up to now we have only mentioned the external resistance, that is, the resistance which the current has to overcome outside the element. The current meets, however, some resistance inside the cell, and this is called internal resistance. It depends on the conducting capacity of the exciting liquid and the size of the metal plates. If the external resistance is great, 500 or more ohms, the internal resistance of the battery can be neglected; if the external resistance is, however, as small as in a cautery burner, the internal resistance is of importance.

Polarisation.—There is another obstacle to the rapid discharge of electricity. The electric current decomposes the fluids through which it is passing; for instance, it decomposes water into hydrogen and oxygen. As soon as the current is closed, bubbles of oxygen appear on the negative, and bubbles of

hydrogen on the positive, metal. The quantity of the produced gas is in proportion to the strength of current. In a cell consisting, for instance, of zinc, sal-ammoniac and silver, the silver becomes covered with gas bubbles very shortly after the circuit is closed, and then the cell consists only of zinc and hydrogen, which has a very much lower E.M.F. than zinc and silver. The strength of current decreases in consequence of this formation of gas, and the first consideration in constructing a cell is to prevent this action, which is called *polarisation.*

Depolarisation.—It can be achieved in different ways: either by shaking off the bubbles mechanically, or by chemical action. The positive metal is then surrounded with materials containing plenty of oxygen, which unites eagerly with the hydrogen and becomes water, annihilating thus the gas bubbles. For this reason some cells contain nitric acid or chromic acid, the Leclanché cell manganese di-oxide, etc.

The *depolarisation*, as we call this process, works perfectly in the chloride of silver or Daniell cell. Such cells are therefore called constant elements, compared with a chromic acid cell, in which the depolarisation is less perfect, and which is called inconstant, because its strength of current decreases after a short time. A Leclanché cell is constant if it is worked for short intervals only or with weak currents; but it is inconstant if it has to yield a current too strong in proportion to its size, or if it remains closed for many hours without rest.

Units.—It became necessary soon to introduce units, in order to be able to express in figures the amount of E.M.F., or the strength of current and the amount of resistance, etc. An International Congress of Electricians agreed to derive the electrical units from the measures for length, weight and time (centimetre, gramme, and second), in order to be able to compare the effects produced by electricity with those produced by other physical forces, and moreover they agreed to name the different units for E.M.F., strength of current, resistance, capacity, etc., after the physicists, who have by their great discoveries materially developed the knowledge of electricity, such as Volta, Ampère, Ohm, Faraday, etc.

The unit of the **E.M.F.,** or potential, which has been chosen is very near the E.M.F. of a Daniell cell, and has been called **Volt.**

The unit of **resistance** is **Ohm.** It equals the resistance of a mercuric column of 1 square millimetre sectional area, and 1·06 metre length at a temperature of 32° F.

The unit of **strength of current** is called **Ampère.** It is the current which an E.M.F. of 1 volt produces in a circuit, the resistance of which is 1 ohm. 1 ampère is too much for medical purposes, and therefore its one-thousandth part, or 1 milliampère, has been adopted as unit for measures of intensity. A source of electricity with an E.M.F. of 1 volt passing through a circuit, the resistance of which amounts to 1,000 ohms, produces in it a current of 1 milliampère.

Watt is the expression for the product of volt and ampère; for instance, a 16 candle-power incandescent lamp requiring either 100 volts and 0·5

ampère, or 200 volts and 0·25 ampère, consumes 50 watts. 736 watts are equal to 1 horse-power.

In the following pages the expression "ampère hour" is sometimes used; this means a current of 1 ampère for one hour, or 2 ampères for thirty minutes, or 1 milliampère for 1,000 hours, etc.

Comparison with a Water Supply.—Electro-motive force, current and resistance, are frequently compared with a water supply, as the conditions are quite similar. Between two tanks of water, connected with a pipe, there will be no water flowing as long as the water in both tanks is at the same level. But if we raise the level of the water in one by raising the tank a current of water will flow through the pipe as long as the difference in level continues to exist. This difference in level is analogous to the electro-motive force, to the volts, in electricity.

The quantity of water which passes through the pipe at a given moment is the current (the ampères). Its intensity, i.e., the number of gallons flowing through the pipe in a given time, depends on two things: (1) The greater the difference in level between the two tanks, the greater will be the pressure or velocity with which the water rushes towards the lower level, *the intensity of the strength of current increases, therefore, in the same proportion as the difference in level (or electro-motive force) increases.* (2) The diameter of the conductor and its quality have, however, an equally important influence on the strength of current. If the pipe is a wide one, smooth, and free from obstructions, the current finds no resistance, and a large number of gallons (or ampères) will flow through the conductor in a given moment. But if the conductor is a narrow one, or fitted with obstructing materials, the discharge will be retarded, a smaller quantity of water will flow through it than would be the case with the better or larger conductor. In other words, *the intensity of the current diminishes as the resistance increases, the strength of current is in inverse proportion to the resistance (the ohms) existing in the circuit.* This is

Ohm's Law.—We will leave now the comparison with the water supply, and return to the electrical terms. We have already seen in the previous statements that an E.M.F. of 1 volt produces 1 ampère in a circuit, the resistance of which is 1 ohm. If we increase the E.M.F., say, to 5 volts, we shall find that the strength of current in the circuit has increased to 5 ampères. The strength of current increases therefore in the same proportion as the E.M.F. In increasing the resistance, however, the strength of the current is diminished; 5 volts can send 1 ampère only through 5 ohms, or only ½ ampère through 10 ohms, etc. The intensity of an electric current is greater, the greater the electro-motive force, and the less the resistance of the conductor. This can be expressed by the formula:—

$$\frac{\text{Electro-motive force}}{\text{Resistance}} = \text{Current; or shorter, } \frac{\text{E.M.F.}}{\text{R.}} = \text{C.}$$

The resistance in this case means all the different resistances which are in the circuit, the resistance in the outer circuit as well as the internal resistance of the battery. This law was discovered by Ohm, and has been named after

him. It is the foundation stone of electrical measurements, and it is practically the only electrical law which has to be considered in using electricity for medical purposes. We will therefore devote a few more remarks to this subject, and quote a few examples.

1. Thirty Leclanché cells, each of which has an E.M.F. of 1·5 volt, and an internal resistance of 0·8 ohm, will, with an external resistance of 4800 ohms, yield

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 4800 \text{ ohms}} = 0{\cdot}0093 \text{ ampère, or} = 9{\cdot}3 \text{ milliampères.}$$

2. If the same battery is used for small incandescent lamps, such as are required for illuminating cavities of the body, the resistance of which varies between 8 and 25 ohms, the current with a lamp of 22 ohms resistance would be

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 22 \text{ ohms}} = 0{\cdot}978 \text{ ampère, or} = 978 \text{ milliampères.}$$

3. If the same battery is connected with a platinum burner, such as is generally used for galvanic cautery, and which has about 0·02 ohm resistance, the 30 cells will yield a current of

$$\frac{45 \text{ volts}}{(30 \times 0{\cdot}8) + 0{\cdot}02 \text{ ohm}} = 1{\cdot}8 \text{ ampère,}$$

a strength of current quite insufficient for making the platinum wire even warm, as the burners generally in use require a current of 18 ampères in order to get red hot.

4. A bichromate battery with two *large* cells, however, which have an E.M.F. of 2 volts each, and only 0·03 ohm internal resistance, will give with the same burner a current of

$$\frac{4 \text{ volts}}{(2 \times 0{\cdot}03) + 0{\cdot}02} = 50 \text{ ampères.}$$

5. With the resistance quoted in Example 1, these two large cells would, however, give only

$$\frac{4 \text{ volts}}{0{\cdot}06 + 4800 \text{ ohms}} = 0{\cdot}0008 \text{ ampère, or} = 0{\cdot}8 \text{ milliampère.}$$

This example shows why the current of a battery with 2 or 4 large cells is sufficient to heat or even to fuse platinum wires, which offer a small resistance; whereas it is too weak to be felt at all if it passes through the high resistance of the human body.

Ohm's law does not only help to find out the strength of current if the E.M.F. and resistance are known, it also enables us to find out the resistance if we know the E.M.F. and strength of current. In this case, Ohm's law reads

$$\frac{\text{E.M.F.}}{\text{Current}} = \text{Resistance.}$$

6. For instance, if the strength of current is 9 milliampères, and the E.M.F. of the cells used 41 volts, the resistance will be:

$$\frac{41 \text{ volts}}{0{\cdot}009 \text{ ampère}} = 4555{\cdot}5 \text{ ohms.}$$

Lastly, you can find out the E.M.F. if you know the resistance and strength of current. The formula then reads as follows: Strength of current $\times$ resistance = E.M.F. For instance:—

7. If the strength of current is 184·4 milliampères, and the total resistance 244 ohms, as shown in Example 2, you get

$$0{\cdot}1844 \text{ ampère} \times 244 \text{ ohms} = 44{\cdot}99 \text{ volts.}$$

Effects produced by the Electric Current.—Before closing these general remarks, we have to mention the principal effects which the current produces.

A magnetic needle is deflected from its direction towards north if a current circulates in its neighbourhood, a quality which is used to detect the presence of a current, and to measure the strength of it. A piece of steel or iron, round which a current passes, becomes magnetic, and has consequently the power to attract other pieces of iron, steel, or nickel. Fluids are decomposed by the current. If we connect two metal or carbon plates with a battery, and immerse them in water, the current will decompose the water; oxygen gas appears at the plate connected with the positive pole (anode), and hydrogen gas on the plate connected with the negative pole (kathode). If the plates are immersed in a solution of metal oxides—for instance, sulphate of copper—metallic copper will be deposited on the plate connected with the negative pole. If we send the current through the human body, at the negative electrode, potassium, sodium, hydrogen, etc., are liberated; and at the positive electrode, oxygen, chlorine, acids, etc. More details about this will be found on pages 17–19. The current heats conductors in passing through them. Bad conductors become more heated than good ones. If a current of 12 ampères passes through a platinum wire of about 0·6 mm. diameter, the wire becomes red hot, so that it can be used for cautery. If a current of 0·3 ampères passes through the thin carbon or metal filament of incandescent lamps, we obtain a brilliant light which we use for illuminating our houses and for examining cavities of the body. This property is now also used to raise the temperature of the human body and to produce fever artificially by means of electric currents.

APPARATUS FOR GALVANISATION AND ELECTROLYSIS.

The Resistance of the Human Body varies widely. If two small metal electrodes of one centimetre diameter each are placed on the *dry* skin, the resistance will be near 100,000 ohms. If we use, however, larger electrodes, about 5 centimetres diameter, cover them with leather, and place them on the skin, after having well soaked them in warm salt water, the resistance will not be more than about 3,000 ohms, and become less, within a short time, under the influence of the current itself. If we introduce an electrode into

the rectum, and place a large electrode, 8 inches diameter, on the abdomen, the resistance will be less than 200 ohms. It is principally the skin which offers the great resistance, whereas the blood, etc., conduct comparatively well. Still, we have in most cases 1,000 to 5,000 ohms resistance to deal with, and therefore a large number of cells is indispensable in order to obtain with these resistances currents varying between 1 and 50 or even more milliampères.

Which are the most suitable Cells ?—It is not my intention to enumerate all the cells which have been invented since Volta till to-day. *Any* cell can be used which is capable of yielding the desired strength of current ; but if we consider convenience, portability, etc., the number of useful cells is limited. In choosing a battery, it is a consideration whether it can be charged by the owner himself, or whether it has to be returned to the maker when exhausted.

The cells most frequently used may be classified in two groups : Cells which contain acids, and where the zincs therefore have to be taken out of the fluid after the battery has been used—Plunge Batteries ; and cells, the exciting fluid of which does not attack the zinc as long as the circuit remains open, and in which the zinc may remain immersed.

Leclanché Cells.—Let us first consider the cell which is more used than all the other cells taken together—the Leclanché cell. For galvanisation and electrolysis, there can hardly be found a cell more reliable and convenient than the Leclanché cell. It is always ready for use, and a well-constructed cell will last for two years without having to be seen to during that time. Moreover, they can be cleaned and refilled without technical aid.

Dry Leclanché Cells.—If portability has to be considered, the dry cells, which belong to the Leclanché type, too, have great advantages over the cells containing fluid, for there is no liquid to be spilled or to corrode the brass parts, and there is no glass, etc., to get broken. They can be sent charged all over the world, and are very suitable for batteries which have to be carried about frequently.

Their only disadvantage is that the cells, after being exhausted, cannot be recharged, but have to be replaced by new ones, and this makes the refilling rather expensive. On the other hand, batteries filled with *good* dry cells will certainly last for fully two years without requiring recharging, and they are less likely to require repairs than those filled with liquid, because accidents like the breaking of glasses cannot happen, so that the difference in the cost of maintaining the batteries is not as great as it appears at first sight.

Acid Cells.—As far as cleanliness and convenience are concerned, the acid cells have disadvantages compared with Leclanché cells. As they must be plunge elements, the vessels cannot be so well closed, and evaporation and spilling cannot be prevented altogether. With daily use an acid battery has to be cleaned and refilled about once in every three months. The refilling, however, may be easily performed even by the most inexperienced. As the acid batteries require less skill to be kept in order than any other

battery, they are especially suitable for use in the Colonies. They have a high E.M.F., 2 volts, so that 22 acid cells are even stronger than 30 Leclanché cells.

Number of Cells.—The number of cells a battery ought to have depends on the purposes for which it is required. Specialists for eye, ear, and throat diseases, and general practitioners, will be able to obtain the strongest currents usually applied to the head with 18 to 24 Leclanché cells; that is, with 25 to 36 volts. 40 to 60 volts are necessary for diagnostic purposes, and for the treatment of nervous and paralytic diseases.

A suitable number of cells alone is not yet sufficient for a medical man; there have to be different appliances for regulating the strength of current, for interrupting, reversing, and measuring the current, and for applying it to the body. The strength of current can be regulated in two ways: either by varying the E.M.F., or by means of artificial resistances. The first mentioned method is more frequently used, and is managed with the help of the current collectors.

Current Collectors.—The current collectors help to increase or diminish the number of cells in the circuit, thus changing the E.M.F., and regulating the strength of current. They ought to be constructed so that the current is never interrupted while the number of cells is being changed, as this would give disagreeable shocks.

A number of pegs, equal to the number of cells in the battery, are arranged in a circle, so that a crank can be brought in contact with every one of these pegs. The cells are connected with these pegs; a wire leads from the first zinc to the negative terminal, another wire from the carbon of the first cell to peg 1, another wire from the carbon of the second cell to peg 2, etc., and one wire leads from the crank to the positive terminal. By turning the crank the number of cells connected with the terminals can thus be conveniently increased or diminished. In order to avoid interrupting the current, the pegs are so arranged that the crank touches the next peg before having quite left the former one.

As long, however, as the crank touches two pegs, for instance pegs 5 and 6, *at the same time*, the sixth cell is short circuited, for the current can pass from the zinc of cell 6, which is connected with the carbon of cell 5, on to peg 5, through the crank to peg 6, and from there back to the carbon of cell 6, without finding on its way any resistance worth mentioning. If this state lasts but shortly, it causes no damage, but if it lasted for any length of time, the short circuited cell would be exhausted. It is therefore important, with all crank collectors, not to let the crank rest so that it can touch two pegs at the same time, as Fig. 1 shows; the crank should always touch one peg only, as shown in Fig. 2. This kind of collector has one drawback

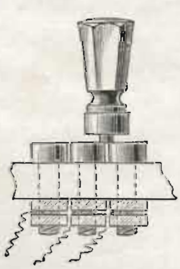


Fig. 1

Fig. 2.

yet, especially if used with batteries containing a great number of cells, viz., that by being always put in the circuit, the first cells of the batteries become used up quicker than the last ones.

Double Collector.—In order to avoid this drawback, I have constructed the double collector. It has two cranks, which are placed on the same axis, but are insulated from one another, and the zinc of the first cell is not connected any more with a terminal, but with an additional peg **0**. One crank is connected with the positive, and the other with the negative terminal. By means of these two cranks any batch of cells may be inserted, and thereby the whole battery can be used up evenly. An index fitted to one of the cranks points to a division, thus showing the number of cells in action.

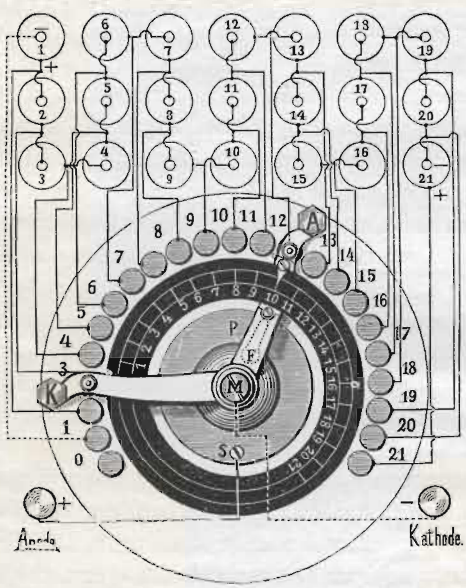


Fig. 3.

Rheostats.—Batteries provided with a good current collector need no rheostat as a rule, but for eye, brain, ear, and dental purposes an increase or decrease of 1·5 volt per cell may cause a slight shock in these most sensitive parts. If a resistance of 1000 to 5000 ohms, which can be varied *gradually, without any jumps*, is inserted in the current, the shocks can be avoided.

Graphite Rheostats.—Graphite is the most suitable material to make rheostats for such a purpose. They are convenient, small, and inexpensive; high or low resistances can be obtained, and they can be so arranged that the current can be varied without giving any shocks. The only disadvantage of graphite rheostats is that the conducting capacity of the graphite varies; this makes these rheostats quite unfit for measuring purposes, but it is of no importance for rheostats required only for regulating the strength of currents.

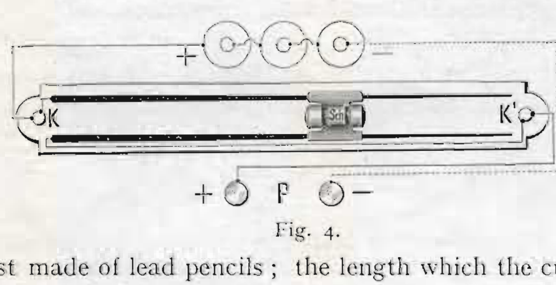


Fig. 4.

They are best made of lead pencils; the length which the current has to pass through can be varied by a spring gliding on the pencils, as shown in the illustration (Fig. 4).

The finest graduations in the strength of current are obtained by means of shunt rheostats like No. 327; they are explained on pages 37 and 38.

Galvanometers.—The great value of galvanometers for medical purposes has been universally recognised. Their purpose is to measure the strength of the current *while it passes through the patient*, and to enable the physician to dose the current accurately, notwithstanding the great difference in the resistance and the sensation in different patients, and notwithstanding the differences of batteries. Galvanometers with a horse-shoe magnet have been used for many years; they are accurate and reliable, but can be used only while standing fairly level, and before starting they have to be adjusted so that **0** of the division comes under the index of the magnet.

Lord Kelvin suggested replacing this permanent magnet by a solenoid, and other scientists made practical use of this idea. Many turns of a fine insulated wire are wound on a frame of aluminium which is suspended between two points so that it can move freely. Two hair springs keep the frame in a certain position, and at the same time conduct the current to the solenoid. As long as a current passes through the solenoid it is attracted or repelled according to the polarity, by a current circulating in the neighbourhood, and the elasticity of the hair springs is the power which has to be overcome and which brings the frame back to its original position as soon as the current ceases. These galvanometers are therefore independent of the terrestrial magnetism, and *can be used in any position*. Moreover, they are protected by a horse-shoe magnet, which acts as a screen against disturbing influences from outside; so that they indicate correctly even near dynamos.

These advantages render the d'Arsonval galvanometers very convenient; their only drawback is that the hair springs are easily damaged if too strong a current is sent through the galvanometer. The old instruments with horse-shoe magnets are less liable to require repair, and I consider them preferable for batteries which have to be handled by inexperienced persons, or which have to be used in Colonies where galvanometers of the d'Arsonval type could not be repaired.

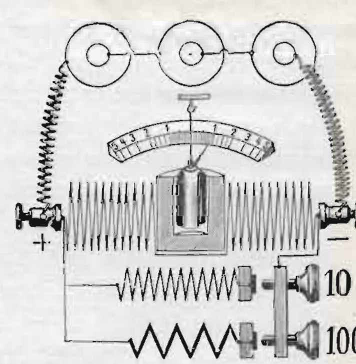


Fig. 5.

Shunt.—All medical galvanometers are divided into milliampères. In order to be able to measure weak currents as well as strong currents with the same instrument, most galvanometers are fitted with one (or two) shunt. As long as this shunt is not used, the whole current has to pass through a long fine wire, which is arranged so as to make the magnet decline. If, however, the shunt is brought into action, the current finds another passage through a thicker wire, which is wound so as *not* to influence the magnet, and in this way the current will divide itself so that its strength in each branch is inversely proportional to the resistance of the wire. If, for instance, the resistance of the shunt wire is chosen so that its resistance is $\frac{1}{10}$th of the resistance

of that wire which makes the needle decline, only $\frac{1}{10}$th of the current will flow through the latter wire and $\frac{9}{10}$ths through the shunt wire. The magnet, therefore, will be influenced by only $\frac{1}{10}$th of the current which actually passes through the galvanometer, and consequently the numbers indicated on the dial have to be multiplied by 10 in order to find the real strength of the current.

Voltmeter.—If the resistance of a milliampèremeter has been increased up to 1,000 ohms, it can be used for measuring E.M.F.'s; for as a current of 1 volt produces 1 M.A. in 1,000 ohms, the number of milliampères is equal to the number of volts *as long as the resistance in the circuit is* 1,000 *ohms*. The body of a patient, or any other unknown resistance, must therefore *not* be in the circuit while the E.M.F. of the cells is being measured.

If the strength of current obtained through a patient is known, and the E.M.F. of the cells which has been used to produce the above strength has been measured in volts in the way just mentioned, the resistance of the patient can be found out with the formula :—

$$\frac{\text{E.M.F.}}{\text{Current}} = \text{Resistance.}$$

(See Example 6, page 6.)

Current Reversers, Current Combiners.—It is important for most physicians to possess an arrangement which makes it possible suddenly to close or interrupt the current, or else to connect with the negative pole the electrode hitherto connected with the positive pole, and *vice versa*. These sudden changes produce contractions of the muscles, the intensity of which depends on the strength of the current, and the sensitiveness of the muscle. They are therefore important for diagnosis. To interrupt and to reverse the current can be managed with one single instrument, of which we add a diagram. The negative pole of the battery is connected with W and N, the positive pole with the metal piece between these two. While the crank points towards N (normal), as the drawing shows, the crank on the right-hand side is connected with the negative pole, and the crank on the left-hand side with the positive pole. By moving the cranks slightly to the left, so that they rest on W and N, both cranks are in contact with the negative pole ; consequently there is no current at all ; but if we move the cranks further, so that they point towards W, the left-hand crank is connected with the negative, and the right-hand crank with the positive pole.

Current Alternator and Combiner.—In order to be able to change the continuous or the faradic current without having to connect the electrodes with other terminals, and in order to be able to apply at the same time continuous and faradic currents combined, Dr. de Watteville has suggested a convenient apparatus, of which we add a diagram, too (Fig. 7). While the cranks point to G, the galvanic current is connected with the terminals ; while the cranks point to F, the faradic current is connected with the terminals ; and while they stand half way (G F), the galvanic and faradic currents are connected with each other in series, i.e., the continuous current has to pass through the bobbin of the induction coil and the patient, and the

faradic current has to pass through the patient and all the cells of the continuous current battery. Thus both currents pass through the patient at the same time.

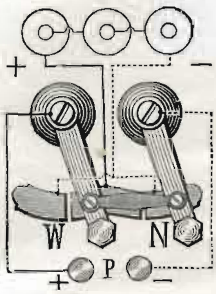


Fig. 6.

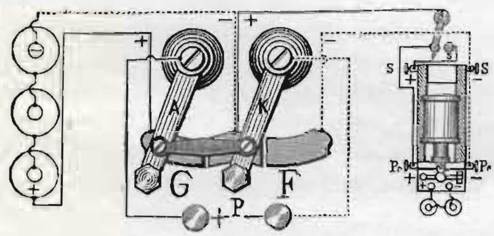


Fig. 7.

Cords and Handles.—Two connecting cords of suitable length, covered with some insulating material, are necessary for conducting the current from the battery to the patient. Insulated copper wire, which is bare for half an inch at both ends, is sufficient; but, on account of the greater flexibility, cords made of very fine wires, terminating on both ends in short and thick wires, are mostly used. They are to be fastened in the handles and in the terminals of the battery. The handles are provided with a terminal for the reception of a connecting cord, and with a thread fitting the electrodes. Many handles are provided with a trigger for making or breaking the current.

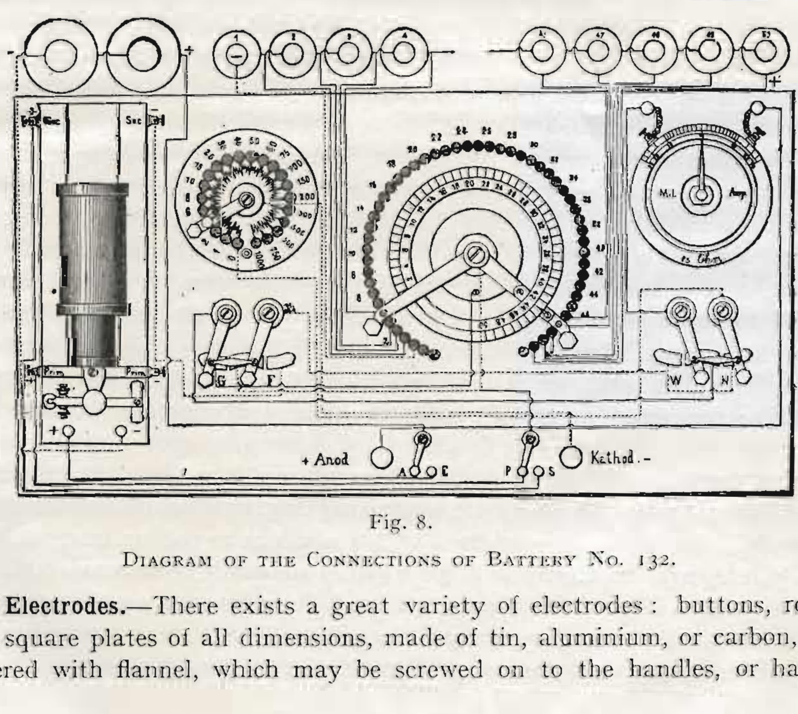


Fig. 8.

Diagram of the Connections of Battery No. 132.

Electrodes.—There exists a great variety of electrodes: buttons, round and square plates of all dimensions, made of tin, aluminium, or carbon, and covered with flannel, which may be screwed on to the handles, or have a

FARADISATION, GALVANISATION, E
CAUTERY, SURGIC LAMPS, MOTORS, E
LIGHT THERAP

terminal to receive the cords direct. Brushes of fine metal wire are used for exciting the muscles and nerves of the skin; wheel electrodes for conveniently changing the place of application, and for combining massage and electricity. Needles are employed for destroying hairs, nævi, tumours, etc. All these electrodes become polarised, and all electrodes made of common metal are subject to oxidation; they ought therefore not to be placed on the mucous membrane unless they are connected with the negative pole. To be used with the positive pole, the electrodes for electrolysis should be of carbon or platinum, unless it is desired to introduce zinc or copper, etc., oxides into the patient's body.

Density of the Current.—The size of the electrodes is of importance. The larger the electrodes, the smaller is the resistance of the human body. With electrodes of ten square inches twice the current can be sent through the body than with electrodes of five square inches surface. This leads us to the density of the current, or, in other words, the proportion of the strength of current to the sectional area of the conductor. If, for instance, with electrodes of three square inches surface 20 milliampères are passing through the body, the current is three times as dense as if electrodes of nine square inches and the same strength of current were used; in other words, in the first case each square inch of the places of application receives 6·6 milliampères, in the second case only 2·2 milliampères. The physiological and chemical effects would in the first case be three times as strong on and near the place where we apply the electrodes as in the second case. On entering the body the current divides itself into numerous loops, and follows the best conducting parts till it reaches the other electrode. The density is greatest where the two electrodes touch the body; it is a little less near the straight line connecting the two electrodes, and smallest in those parts of the body which are most distant from the electrodes; but experiment shows that even those parts are reached by some small part of the current.

The effect of the current is frequently desired in one definite spot only, but as we necessarily require two electrodes to complete the circuit, they are chosen of very different diameter: a small one (active electrode), to concentrate the current on the nerve or muscle, etc., which is to be influenced by the current, and a large one (called the indifferent electrode), which may be applied to any easily accessible part of the body. If the latter electrode is chosen sufficiently large, undesired effects, such as pain or blisters, etc., will be avoided. If a sensitive patient or a child is to be treated, the electrodes should be moistened in a solution of chloride of ammonium, because this causes less pain than sodium chloride.

Electrolysis.—This is of special importance if the chemical properties of the current are to be used for destroying any tissues, etc. (electrolysis). If, for instance, a needle connected with the negative pole is inserted close to a follicle, and an electrode of two inches diameter, connected with the positive pole, is held with the patient's hand, the current is equally strong in both electrodes; but in the one the whole effect of the current is concentrated on a needle's point, and the chemical action of 1 milliampère suffices already

to destroy the follicle, so that the hair can be extracted after a few seconds. The chemical action on the other electrode, however, is divided over so large a surface that the current mentioned will leave no visible effect.

Faults.—It is not an easy undertaking to describe in a few words the faults which may occur in a battery, and how they can be found out and rectified. The preceding sections, explaining the batteries and accessories, will enable any one who takes an interest in his instruments to find out the reason of any disturbance ; whereas for him who does not trouble to learn to understand his battery, any number of pages about this theme will be insufficient, for he will remain dependent on the help of an electrician. If a battery does not work, the only reasonable thing to do is to ascertain where the fault is, whether it is in the cells, or in the connection between the cells and the terminals, or in the cords, handles, etc. Frequently the fault will be found in the connecting cords. They are liable to break, and this shows itself by their too great flexibility: they are cut off then up to the unspoiled part. In all batteries with a great number of elements, a spark appears if the two ends of the connecting cords are brought in contact and separated again. If no spark is seen, fasten one end of a cord to a terminal, and touch with the other end the other terminal. If still no spark is visible, touch peg 1 with one end of a cord, and with the other end touch the last peg of the collector, and if there is still no spark, try with groups of, say, five elements each, either on the pegs of the current collector or directly on the terminals of the cells. If the elements are not very old, a spark will be obtained from several of these groups, and the faulty cells may be singled out. A whole battery may fail because one of the many screws on the cells may have got loose, on account of differences of temperature or shaking in the transit, for a loose screw no longer makes any contact with the wire which connects the cell with the next one. This can easily be rectified by tightening the screw. A galvanometer makes it much easier to find such a fault ; the cords are connected with the galvanometer, and the other ends are placed first on pegs 1 and 2, then on pegs 2 and 3, etc. ; in this way each cell can be tested, and a fault found out at once. In batteries provided with a double collector it is simpler still. The tongue is a sensitive galvanoscope, too. If we touch with it two wires connected with a cell, we feel a peculiar taste if the cell is working. We strongly recommend, however, to try this experiment with groups of not more than ten cells only.

It is rare that a fault occurs in the connections between the cells and the current collector, the wires being mostly well protected and all the invisible connections being soldered. The pegs of the current collector, as well as the current reverser, are liable to become oxidised, and have to be cleaned occasionally with fine emery paper ; dust between the pegs should be removed with a brush. The screws which keep the crank of the current collector and reverser on their axes may become loose and have to be tightened. The handles with an interrupter may fail to make contact through oxidation, or through the spring being loose. *Cords, handles, or wet electrodes ought never to be placed on the current collector, as they may cause short circuit.*

We have yet to mention the faults which are caused by false application. Some people believe in being able to test a battery if they touch with dry fingers the varnished terminals, or else the ends of the connecting cords. Of course, in both cases, the current is exceedingly weak on account of the very high resistance, and can hardly be felt even by experienced persons. Currents of a few milliampères are felt by most patients only if they are suddenly closed or broken, and whenever a battery is tested, the only proper way to do it is to soak the electrodes in warm salt water, and to apply them as in real use.

Current supplied from Dynamos.—The apparatus required for utilising the currents supplied for lighting houses, for galvanisation and electrolysis, are explained on pages 34-48.

SOMETHING ABOUT IONS AND IONIC MEDICATION.

The conductors of electricity are divided into two classes: the dry conductors, *i.e.*, the metals, are called conductors of the 1st class; and all liquids conducting electricity, as saline solutions or acids, are called conductors of the 2nd class.

Resistance of the Human Body.—The dry parts, such as hairs, nails, etc., do not conduct electricity, nor do dry bones, dried muscle or fat. The conductivity of the body is entirely due to the saline solutions present in it. The dry skin does not conduct electricity either, and if we can pass a current through the skin, it is only because numerous fine pores traverse it, and the moisture contained in these pores conducts the electricity. The resistance of the skin is greatest where there are the fewest pores, and where the skin is thickest—for instance, at the palms of the hands. The resistance is lowest on those parts where perspiration is greatest, *i.e.*, the armpits, etc. The resistance at the latter part is only about $\frac{1}{10}$th of the resistance of the palms of the hands.

To make the skin conduct, we cover the electrodes to be used with some absorbent material, like cotton, lint, etc., soak them in warm water, and press them firmly against the skin. The larger the size of the electrodes chosen, the smaller will be the resistance of the skin, because a greater number of pores then become available as conductors.

The fluids circulating in the human body consist largely of saline solutions, which conduct the current well. Compared with the resistance of the skin, the mucous membranes, the blood, urine, etc., offer scarcely any resistance. If we connect two button-shaped electrodes with 3 or 4 Leclanché cells, and press one on the right, the other on the left cheek, a current of about 1 M.A. will pass. If we apply one of the electrodes inside the mouth, the current rises to about 2 M.A., and it is immaterial whether the electrode inside the mouth is applied on the same side on which the outer electrode is pressed, or on the opposite side, or on the tongue, the increase in the distance to be traversed by the current is immaterial compared with the resistance of the skin. If both electrodes are applied inside, the current will rise to over 3 M.A.

Something about Ions.—All the fluids conducting electricity are either solutions of salts or acids, and are called electrolytes. Pure water, alcohol, glycerine, oils, etc., do not conduct electricity. Each salt contains a metal and an acid radical. If we place two platinum electrodes in a saline solution and connect them with a galvanic cell, the metal contained in the solution appears at the electrode connected with the negative pole, the cathode, and the acid or hydroxyl appears at the electrode connected with the positive pole, the anode. Hydrogen behaves like a metal, and appears at the cathode. Iodine, chlorine, etc., wander from the negative towards the positive electrode.

The passage of an electric current through an electrolyte produces therefore invariably a certain movement of the atoms contained in the solution, which are the carriers of the current. The effect is apparent only **at** the electrodes, not **between** them. An explanation for this has been given by Claudius Arrhenius. According to his theory, which has been generally accepted, every composite molecule—for instance, chloride of sodium $NaCl$—consists of two parts, having electric charges of opposite polarity: the metal part has a positive, the acid part a negative charge. These opposite electric charges cause them to attract one another, and while the two partners are combined, the charges neutralize one another and the molecule appears therefore electrically neutral.

When the salts are being dissolved, for instance in water, the molecules move about, some come in collision with others, and many become dissociated into atoms. At the moment the molecules dissociate and split up into atoms, the electric charges peculiar to them reappear, and the electrically charged atoms are called Ions.

At the suggestion of Faraday we call the acid ions appearing at the anode or positive pole, the Anions, which, in chemistry are given the sign ⊖. The metal ions arriving at the negative pole or cathode, are called the Kations and are given the sign ⊕.

If two electrodes are placed in an electrolyte, the one charged with positive electricity will attract all the anions, *i.e.*, all the acid atoms, the other electrode charged with negative electricity will attract all the kations, *i.e.*, the metal, alkaloid or hydrogen atoms charged with positive electricity. The kations give up their charges at the cathode and adhere to it, the anions move towards the anode, give up their charges and escape as gases or enter other combinations. The current does not therefore decompose the electrolyte, but causes only a movement of the ions.

This has given a new aspect to the theory of electricity: it is now considered as matter, consisting of atoms like other matter; the atoms of electricity are called electrons. They must be infinitely smaller yet than the atoms of hydrogen. It is not the object of this pamphlet to follow these theories at any length, but as far as the practical side of medical electricity is affected, I have to devote yet a little more space to this subject.

According to our present knowledge the electric current does not produce any other effect on the human body except this movement of ions, and we conclude therefore that this movement of ions is the cause of all the physiological effects produced by the current in the human body.

Ionic Medication.—The property of the continuous current to transport ions through the skin and similar membranes is being utilized frequently to introduce drugs by means of an electric current into the human body, instead of swallowing them or injecting them with a syringe.

Any salt or alkaloid or acid can thus be introduced, and the effects produced by the various drugs correspond to the chemical and physiological effect peculiar to the salts or acids used. The copper ion causes dry necrosis of the skin, the mercury ion liquefies the tissues, the zinc ion is a powerful antiseptic, etc., morphia, atropine, cocaine, adrenalin, etc., can all be used. Iodides and bromides can thus be introduced in comparatively large quantities without affecting the skin.

By employing electricity we can localize the effect of the drugs to the parts we wish to affect, provided that they are near the surface. In a test-tube filled with gelatin or coagulated albumen we can watch the steady progress right through the length of the tube, but we cannot force drugs right through the living body. If we apply an anode soaked, for instance, in iodide of lithium solution on the chest, and the cathode at the back, we shall never find any trace of lithium at the cathode, for two reasons:

The ions move rather slowly, owing to the resistance they find in the fluids and the membranes they have to traverse. The rate of progress depends on the strength of the current × the time the current is applied, but with the average currents used, the ions will not penetrate deeper than 2 or 3 ctm. into the body. As soon as they reach larger blood vessels, they are carried away by the more swiftly moving stream of blood, and can soon be traced in the urine. Other ions are brought instead within the sphere of action of the electric current by the blood, and are moved towards the cathode, but those which started originally from one electrode do not continue their journey right through the body, and will not arrive at the opposite electrode.

We cannot therefore concentrate the action of a drug introduced in this manner on a deep-seated organ like the heart or the kidneys, but for local applications near the surface this method is much more effective than the swallowing of drugs. It is of great advantage in the treatment of many diseases of the skin. Ointments, liniments, etc., rubbed on the skin are useful only as germicides, emollients, caustics, etc., but they do not enter the skin, which excretes only, but does not absorb. But any drug which is soluble in water can be introduced through the skin with the help of an electric current. The ions enter the minutest cells, remain there locked up for some time, and are constantly replaced by new arrivals; we can thus obtain with quite small doses much greater local results than those which can be reached even by large doses swallowed by the mouth, and the undesired

effects produced by some drugs on the stomach, etc., are thus avoided. The ionic medication is also more efficient than hypodermic injections, owing to the finer distribution of the ions in the small cells before they are reached and washed away by the blood.

The quantities which are introduced are small, too, and are in proportion to the strength of current used × the length of time during which it is applied. With a current of 20 M.A. applied for 25 minutes, we transport, for instance, 0·0063 gramme $\ominus$ Cl through any part of the body traversed by this current. A current of 10 M.A. will introduce 20·7 milligrammes of strychnine into the circulation within ten minutes.

The **technique of ionic medication** is simple enough. A number of special electrodes made of platinum, carbon, zinc, copper, etc., have been constructed, and are certainly convenient in many cases; if zinc or copper ions are to be introduced, it is an advantage to use electrodes consisting of these metals, but any electrode can be used for ionic medication, provided there is between the electrode and the skin a **thick** layer of 6 to 12 sheets of pure lint, or one or two layers of pure felt, or some similar absorbent material, which has to be soaked in a 1 or 2 per cent solution of the drugs to be introduced. Even if the electrodes should consist of some material which we do not wish to enter the body, for instance lead, the lead ions liberated by the current cannot traverse the thick layers of absorbent material in the time usually given for an application. It is however necessary to use **clean** layers of lint, felt, etc.; if the same pieces were used repeatedly, the undesired ions which entered the absorbent materials at previous sittings would reach the body ultimately.

To enable us to use a fairly strong current without giving the patient undue pain, **large** electrodes, covering the affected area, have frequently to be employed, and we must take care that they **press evenly on the skin to make a uniform good contact.** On a shoulder, knee, hip, etc., this can best be done by using chain electrodes, which may be fastened by a binder over the absorbent material. If the electrodes press unevenly or are partly dry, the current will concentrate on the parts making better contact and may cause irritation or pain to such an extent that the treatment may have to be suspended for some time. In extreme cases even blisters or a slough may be produced.

For cavities like the ear, rectum, urethra, vagina, etc., specula, bougies, or irrigators may be introduced and filled with a solution of the drugs to be used. The connection with the current can be made by a platinum wire projecting into the solution.

Currents of 20 to 50 volts are usually employed; in most cases a 32-cell Leclanché battery, giving a maximum of 48 volts will be found sufficient. If a continuous current from the electric mains for lighting purposes is available, it can be used too with a suitable rheostat to reduce and control the voltage. The current has to be increased or decreased **gradually,** nobody can tolerate without pain the **sudden** introduction of an E.M.F. of 20 or more volts, but such a voltage can be borne quite well if it is introduced or removed gradually.

Prof. Leduc recommends to use a current up to 2 M.A. per square centimeter surface of the electrodes, and 2 per cent solutions of pure drugs. If we wish to introduce zinc, copper, cocaine, etc., we have to apply the **positive** electrode, the anode to the absorbent material which has been soaked in the solution and applied near the spot where we wish the drugs to act; but if salicylates, iodine, or acids have to be introduced, the **negative** electrode is applied to the absorbent materials.

Ionic medication can also be applied by placing hands, or arms, or feet in basins filled with the solutions to be introduced, carbon electrodes convey the current from the battery to the solution in the basin. The so-called 4-cell bath can also be used equally well.

Ionic medication has been advanced considerably by Prof. Leduc of Nantes and Dr. Lewis Jones of London, and further particulars will be found in the books of these authorities.

The **chemical and physical effects of a continuous current** on the living body. —If we were to use **dry** metal electrodes, ⊖ Cl will appear at the anode and will form hydrochloric acid and oxygen. At the cathode hydrogen and caustic soda are formed in consequence of the ionic migration, the former escapes as gas, the latter enters a chemical combination and ⊖ OH is left. At both poles, caustics are thus formed, and if the current has a strength of only 1 M.A. it will irritate the skin after a short time, and will cause pain under such conditions. To avoid this, we cover the electrodes with some moisture-absorbing materials, cotton or lint, etc., and soak them well in water. The caustic effects will not appear then for a considerable time.

If strong currents are to be applied, the caustic effects and pain can be avoided if we soak the anode in a weak solution of bicarbonate of soda. The carbonate ion ⊖ $2CO_3$ moves towards the electrode and escapes as gas, without decomposing the water or the electrode, and thereby forming caustic ions. The cathode loses its caustic effects if it remains soaked with very diluted hydrochloric acid. The hydrogen ion H ⊕ appearing at the electrode escapes as gas without decomposing the water, and thereby causing the formation of a hydroxyl ion ⊕ OH.

The **physiological effects** *of the continuous current.*—The migration of millions of ions causes yet other effects beyond those due to chemical or electrolytic action mentioned above. Though the individual atom or ion is very small, their number is very great; they are moved out of their usual position and track, and are compelled to traverse the membranes and tissues of the millions of minute cells constituting the body. Some of the effects produced by these wandering ions are felt immediately, and can be observed by the eye, others become apparent only later on.

While the current is applied, the sensibility becomes reduced near the anode, increased near the cathode. A little while after the application, the

sensibility is increased near the anode, as well as near the cathode, and remains in this condition for a considerable time.

If even quite a weak current is suddenly closed or suddenly interrupted, the patient feels a shock. If currents above a certain strength are used, the sudden closing or breaking causes the muscles to contract in such a manner that it becomes plainly visible to the eye. The shocks or contractions become more violent if, instead of making or breaking the current, its direction is suddenly reversed; in this case all the ions have to turn about, and this causes stronger contractions than when they are merely set in motion. These contractions are useful for diagnostic purposes, to test the degeneration of muscles. The intensity of the shocks increases with the intensity of the current used, and currents of 100 or more volts, suddenly closed, may even cause instantaneous death by the mere movement of the ions, without producing any visible lesion. On the other hand, with the so-called high-frequency currents, in which the direction of the currents is reversed over 100 thousand times every second, we can stand very large doses with impunity, without even feeling any shock, because the duration of the single impulses is so extremely short, and finished long before the ions had time to begin to move. The high-frequency currents have therefore no ionic effect on the human body, their action is most likely due to thermal effects only. If the currents are of sufficient strength, they cause a rise in the temperature of the patient's body, just as currents heat the filaments of incandescent lamps. The currents used for galvanisation and faradisation are much too weak to cause any noticeable increase in the temperature of the patient.

When a current is applied, the muscles of the vessels contract at first and cause anæmia; but after a short time they relax and expand considerably, and a condition of hyperæmia is plainly apparent from the colour of the skin. Hyperæmia is an important factor in nearly all the methods used in physical therapeutics, in enabling us to attract considerable quantities of blood to parts of the surface chosen by us, to relieve congestions of deeper parts, and to influence the circulation, the blood pressure, the breathing, and, to a certain extent, some functions of nerves.

Any disturbance of the molecular equilibrium has a stimulating effect on the activity of the protoplasm and cells. It is undoubted that the migration of these millions of ions caused by the application of an electric current must have a considerable influence on the metabolism of the cells, and many of the good results which have been obtained and described by conscientious and trustworthy physicians, and which have been repeated over and over again by others, are certainly due to the stimulating effect produced by the migration of the ions. It would be unreasonable to doubt or dispute these good results, or to attribute them merely to suggestion, simply because we have not yet a complete explanation of all these processes. We do not doubt or dispute the actions of drugs, though the "why" and "how" many of them act is quite as much a mystery up to now as some of the physiological results obtained with electric currents.

BICHROMATE BATTERIES FOR CAUTERY, SPARK COILS &c., INSTRUMENTS FOR CAUTERY.

A strong current is required for rendering platinum wires of the thickness needed for cautery operations incandescent, for most of the burners require 10 to 18 ampères (10,000 to 18,000 milliampères), and in order to keep a current of this strength constant, even for one minute only, *large* cells are absolutely necessary. On the other hand, platinum burners have a very low resistance—burner, handles and cords together about 0·06 ohm. If the cells have a small internal resistance too, for instance, 0·06 ohm per cell, two cells of 1·5 volt each are already sufficient for producing the necessary strength of current with these resistances, for

$$\frac{3 \text{ volts}}{0{\cdot}06 + 0{\cdot}12 \text{ ohm}} = 16{\cdot}6 \text{ ampères.}$$

The requirements for cautery are therefore totally different from those for galvanisation and electrolysis. In the latter case many cells are needed to force even a weak current through the high resistance of the human body. The cells, however, can be small, because the strongest current used rarely exceeds 100 milliampères. For cautery, the E.M.F. of two cells is already sufficient on account of the very small external resistance, but the cells have to be of large size, as the current required must be more than 1,000 times as strong as the currents generally used for galvanisation.

Connection of Cells.—Up to now only *one* method of arranging the cells has been mentioned, the connection "*in series*," for high external resistances. The cells can, however, be arranged so that the carbon of the first cell is connected with the carbon of the second, and the zinc of the first with the zinc of the second cell, etc., and this is called connecting the cells "*parallel*." The E.M.F. *does not* increase thereby, no matter how many cells are connected in this way, but the surface of the metal or carbon plates increases, and consequently the internal resistance diminishes, with each additional cell. Two cells connected in this way are equal to one single cell of double size, and this is an advantage for galvanic cautery, for by lessening the internal resistance we enable it to yield, with small external resistance, a stronger current. Moreover, we double the constancy, for large plates do not polarise as quickly as small ones do, and the capacity in ampère hours of two cells connected parallel, is twice as large as the capacity

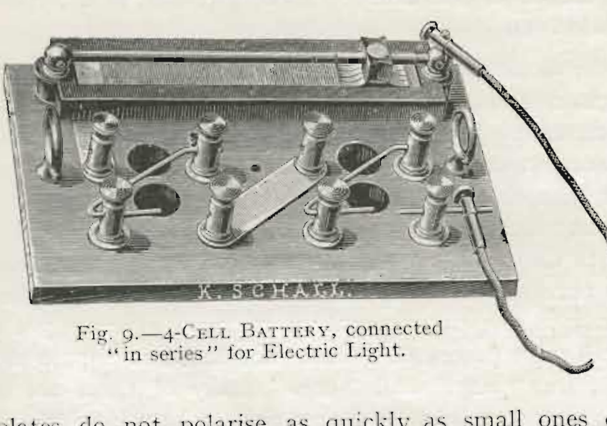


Fig. 9.—4-Cell Battery, connected "in series" for Electric Light.

of two cells connected in series. There are yet some other combinations possible. The two diagrams show the two different ways of connecting the 4 cells of a cautery battery. As already mentioned, the E.M.F. of two cells is sufficient to produce with so small a resistance the necessary strength of current; for wire loops, however, 3 to 4 cells are necessary, and the batteries most frequently used for cautery have 4 cells. If batteries are constructed with more than 4 cells, this is partly done in order to be able to connect the cells parallel in the way above mentioned, and partly to use them for surgical lamps or spark coils as well.

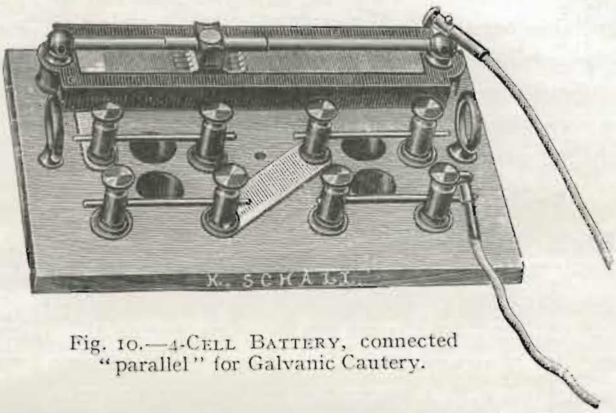


Fig. 10.—4-Cell Battery, connected "parallel" for Galvanic Cautery.

Which are the most suitable Elements? Bichromate Cells.—There is no great variety of cells with a sufficiently small internal resistance. Bichromate elements are most frequently used for cautery. The chief objection to them is their want of constancy. If, however, the cells are not made too small, they are sufficiently constant for all cautery operations; for a cell of 3 by $5\frac{1}{2}$ by $6\frac{1}{2}$ inches will keep a burner requiring 18 ampères incandescent for about twenty minutes. They are powerful, their E.M.F. being 2 volts, and they are easily put in action. They can quickly be re-filled, and can be easily kept in order by anybody, so that they are very suitable for medical men who do not wish to be dependent on the electrician's help. The zincs in bichromate batteries should be well amalgamated, and for this reason the zincs in our batteries consist of an alloy of 10 parts of zinc and 1 part of mercury, and moreover the acid contains some mercury too.

Rheostats for Batteries.—A rheostat is most convenient with every battery for regulating the strength of current for cautery. A bichromate battery, without a rheostat, cannot be plunged in deeper than is necessary for just making the wire red hot; on account of polarisation, etc., the current diminishes pretty quickly, and the battery ought to be gradually immersed deeper, in order to keep the burner at the same temperature. A rheostat, however, enables you to immerse the battery completely from the beginning, and to reduce the current by inserting an artificial resistance. As the cells have a larger surface, the strength of current remains constant for a much longer time, so that the operator can give his whole attention to the patient. Rheostats are quite indispensable for accumulators, as without them all burners would be destroyed at once.

It is best to begin by inserting the whole resistance, and after the circuit has been closed, to diminish it gradually, by moving the spring, until the platinum has reached the proper temperature for operations.

Cords and Burners.—Connecting cords for cautery ought to be thick, because if thin they would either become too warm, or else weaken the current considerably.

The platinum burners are soldered on to copper wires of different lengths, suitable for the nose, larynx, ear, etc. The copper wires are insulated from one another with silk, which is wound round them in the shape of an 8, but where the copper touches the platinum they grow so warm that the silk would become black, and therefore they are for a short distance insulated with shellac varnish only.

Faults.—In order to rectify any fault, it is necessary with these batteries, too, to find the seat of the defect, and it will then be easy to remove it. The burners are apt to fail because the two copper wires may touch at the end near the platinum, so that the current can pass directly from one copper wire into the other without reaching the platinum at all. This is a frequent fault, and can be recognized by the copper wires getting very hot. They should be separated with a finger nail so far that you can see between them all along. If the platinum of a burner has been fused by too strong a current, a new platinum wire must be soldered on. If the battery fails, in spite of the burner being all right, you should take off the handle, and let the two ends of the connecting cords touch each other. If they yield a strong, crackling spark, the fault is in the handle—the place of contact is oxidised, and has to be cleaned with fine emery paper; but if the connecting cords yield but a weak spark, or none at all, the fault lies further back. A weak spark shows that the connections, etc., are in order, but that the battery is too weak. With bichromate batteries, this fault can be easily removed. If the solution has turned green, it is exhausted, and the battery must be cleaned and refilled. If the fluid is still red or brown, a cell has been short circuited by carbon and zinc touching one another, *or else the zincs are covered with a coating of oxide,* which can be best removed if they are screwed off and cleaned under a water tap with an old nail-brush, until the bright zinc reappears. If there is no spark at all, although the battery can hardly be exhausted, you should remove the connecting cords and see whether the cells yield a spark, if the end terminals are connected with a short wire; if this gives a spark, the rheostat or the cords are at fault. A fault in the cords is indicated by excessive flexibility near the broken place. If, however, there is no spark, either the connection amongst the cells is at fault, or the arrangement of the cells is incomplete; this is found out if each element is tested singly at first, and afterwards groups of two or more cells; or the battery is exhausted, and you have to clean and re-charge it as already stated.

For apparatus required to control the current supplied for lighting houses, for cautery or spark coils, see pages 39-41.

ACCUMULATORS.

The Advantages and Disadvantages of Accumulators or Secondary Batteries, compared with primary galvanic cells, are as follows. Their E.M.F. (2 volts) is higher and their internal resistance lower than in all other cells, and for this reason they produce a remarkably powerful current, which, being completely depolarised, is perfectly constant until the accumulator is nearly exhausted. The acid is not used up, and therefore has not to be renewed except to make up for the loss by evaporation. Accumulators are specially suitable for spark coils. They are convenient for motors, cautery burners, and small lamps.

Their Disadvantages are, that they require a more scientific and careful treatment, more frequent attention, and more time for being recharged than primary batteries do ; that they are more easily damaged, and that for repairs they have to be returned to the manufacturer.

They consist of lead plates immersed in diluted sulphuric acid ; 136 volumes of *pure* strong sulphuric acid are mixed with 1,000 volumes of distilled water. The mixture ought to have a specific gravity of 1·15, or 36 Baumé.

Chemical Process.—The sulphuric acid causes a thin layer of lead to change into sulphate of lead. An electrical current sent through such a cell produces electrolysis ; oxygen appears on the plates connected with the + pole, and converts the sulphate of lead into peroxide of lead. On the plates connected with the negative pole, hydrogen appears, and reduces the sulphate of lead into a porous, spongy mass of metallic lead. If the action of the current lasts long enough, the plates connected with the positive pole are converted entirely into peroxide of lead, and the negative plates into spongy metallic lead. Ultimately, oxygen and hydrogen, finding nothing left to act upon, escape as gas, and it would be waste to let the current act any longer.

In this way, chemical changes have been effected by means of an electrical current. We have two different plates now, and the chemical action of the acid produces an E.M.F. If the plates are connected by means of a conductor, an electrical current is started *in opposite direction* of the charging current. During the discharge, the chemical process gets reversed ; the plates which had been covered with oxygen during the charging become, during the discharge, covered with hydrogen, which combines with the oxygen contained in the peroxide, and produces sulphate of lead. The oxygen generated on the negative plates combines with the acid, and changes the metallic lead also into sulphate of lead. As soon as both plates have returned to their original condition, all difference between them has ceased to exist, the E.M.F. stops, and with it the discharging current. The acid too has regained its original strength, and thus the process can be repeated any number of times.

The only difference between primary cells and accumulators is, that primary cells have to be charged with chemicals which have to be prepared beforehand, and which, when used up, have to be removed and replaced by a fresh supply. In the accumulators, it is the action of an electrical current which generates the chemicals required to produce the E.M.F., and a current will regenerate them as often as desired, without a renewal of acid.

Capacity.—The capacity of the accumulators, i.e., the quantity of electrical energy which they can store, in form of chemicals, is in direct proportion to the quantity of lead which they contain. Moreover, the current by which an accumulator is charged or discharged, has to be in proportion to its capacity. If the density of current (the number of milliampères per square centimetre) is too great, the oxygen cannot change the sulphate quickly enough, and

therefore part of it escapes as gas unutilised. In discharging too heavy a current, the cell will become polarised in consequence of the same difficulty. There is no fixed rule how many ampères may be used for charging or discharging accumulators; this depends on the capacity of the accumulators, and on the special construction of the plates. As a general rule, the charging current ought not to exceed one-fifth, and the discharging current one-fourth of the capacity; that is to say, a 20-ampère hour accumulator should be charged with not more than 4 ampères, and discharged with not more than 5 ampères. Some kinds are made specially so that they can stand a considerably higher rate of discharge. If the strength of the discharging current is exceeded, the efficiency decreases, and instead of 20, only 15 or 10 ampère hours will be obtained from the accumulator. In extreme cases, when an accumulator is short circuited, the plates are destroyed by crumbling up.

Charged Accumulators have the tendency to Discharge slowly without being connected with a conductor, in consequence of defects in the insulation, and also on account of impurities of the acid. Sulphate of lead is therefore gradually being formed even while the accumulators are standing unused. The sulphate, when freshly formed, is fine and soluble, and can be changed into peroxide by means of a current. After some time, however, it assumes a crystalline form, becomes insoluble, and cannot then be changed any more into peroxide by the current. The capacity of the accumulators decreases therefore in proportion to the increase of the sulphate of lead crystals. Plates which have become defective in this way have to be replaced by new ones.

The following rules can be derived from the above :—

(1) The capacity of the cells must be in direct proportion to the discharging current. If, for instance, the accumulators are intended for working spark coils or cautery burners, they should be of a size which can discharge up to 18 ampères without becoming damaged. Cells which are too small for the work required of them will soon be destroyed.

(2) Short circuit must be avoided. Terminals must not be connected with a wire in order to see a spark, as it tends to destroy the plates. The connecting cords should be attached to the spark coil or cautery handle *before* the other ends are connected with the accumulator terminals.

(3) In charging, the + pole of the changing current has to be connected with the + pole of the accumulator. The latter is usually painted red. If by mistake the wrong poles are connected, the accumulators discharge rapidly and are destroyed.

(4) Accumulators must be re-charged frequently, *whether used or not.* If this is neglected their capacity is diminished, on account of the formation of insoluble sulphate of lead. This explains why accumulators give every satisfaction when used in lighting stations, where they are re-charged daily, or at least once a week, but many medical men are under the false impression that the accumulators need no re-charging so long as they still yield a current. The smaller the accumulators, the more frequently have they to be re-charged. Accumulators of 20-ampère hour capacity and more, ought to be re-charged *at least once a month* to keep them in good condition.

The charging of the accumulators is best done by dynamos. Where the *continuous* current is laid on for illuminating purposes, medical men can easily do it themselves. One or several incandescent lamps are inserted in the circuit. By means of pole-finding paper, the polarity is ascertained (the negative pole makes a red stain on the moist paper), and the charging is continued till gas bubbles appear, the acid turns milky and makes a hissing noise. A 20-ampère hour accumulator will take about twenty hours for charging with a 32 candle-power lamp on a 100-volt circuit. If four lamps of this same candle power are connected parallel, the charging will be finished in five hours.

The plates *must be fully covered by the acid,* and if the latter has partly evaporated on account of too prolonged charging, or for some other reason, it has to be brought to its original level by some fresh acid.

A Voltmeter is very convenient for controlling accumulators. While in good condition, each cell gives fully 2 volts. If the E.M.F. falls to 1·8 volt per cell, the charge is nearly exhausted, *and the accumulator should be re-charged at once.*

BATTERIES AND INSTRUMENTS FOR ELECTRIC LIGHT.

Advantages of the Electric Light.—The electric light is white and intense, it develops scarcely any heat, and the lamps need not be held upright, as oil lamps, for instance; they can be used in any position and can be brought close to the object which has to be examined. Moreover, the doctor is independent of the focal length of a reflecting mirror. These facts help to make incandescent lamps most useful for medical purposes, in the consulting room, but more especially in the patient's house, where often a wax candle is the only other available light which might be used. The electric light is, moreover, the only kind of light which can be introduced into the human body, either for examinations of cavities like the bladder, or to make part of the body transparent (antrum) for diagnostic purposes.

Strength of Current.—The filaments of the surgical lamp require a current of 0·3 to 0·7 ampères to become white hot, and the resistance of the lamp is chosen so that 4 to 12 volts can produce this current. The size of the cells employed will depend on the time for which the light is required.

The most suitable Cells are 2 to 4 accumulators or bichromate cells, or 3 to 8 Leclanché cells, connected in series. Accumulators are smaller than any other battery of similar power, but to keep them in good order they must be re-charged regularly about once in every four weeks, and for this reason they are to be recommended only where a continuous current from a dynamo is within convenient reach for re-charging. Full particulars will be found on pages 18–20.

The Leclanché cells, dry or liquid, if not chosen too small, will be found reliable for one or two years, without requiring any attention for re-charging during this time. The liquid cells can be re-charged; the dry cells have to be replaced by new ones, but there is no danger of breaking or spilling with the latter.

The current from the main cannot be used directly, because there is no room for a filament of sufficient resistance in the small bulbs; but the voltage may be reduced either by transformers or rheostats. Full particulars about these will be found on page 41.

Rheostats are most convenient, and the small expense of obtaining one will be made up in a short time, because fewer lamps will be destroyed by using them. The rheostat had best be fixed on the battery, as in this way it may be used for several instruments.

The amount of light which a lamp can yield may not be increased to any extent by increasing the strength of current, without damaging the lamp. The carbon filament should be a little more than yellow. If this degree of incandescence is exceeded, the lamp can certainly give twice as much light as under normal circumstances, but its life is considerably shortened, as the filament evaporates by being over-heated. If the current which the lamp requires is not known, the whole resistance of the rheostat should be inserted, and the current can then be increased by diminishing the resistance until white heat is obtained.

Faults.—If the instrument fails, examine first of all the lamp. The lamps are provided with an arrangement allowing them to be exchanged easily—in most cases they are fitted with a screw, *which has to be well screwed home.* The lamps may become loosened by shaking, heating, etc.; when the light fails, this ought to be seen to first. The carbon filament may be burned through, and this frequently shows itself by the glass looking grey. In this case the lamp has to be replaced by a new one. But if the lamp and its connection with the instrument are in good order, and still there is no light, the fault is likely to be in the battery, and may be found out in the way mentioned already under galvanic cautery; for experience shows that, with the exception of the lamps, the illuminating instrument itself is hardly ever in want of repair. The sparks obtained from batteries for the electric light are not nearly as strong as those yielded by the cautery batteries, and therefore it requires more attention, especially in daylight, to find out whether the battery gives a spark or not.

FARADISATION.

Induction.—The genius of Faraday taught the world another way of producing electricity, and so thoroughly has he done his work, that *all* that we now know about induction is the result of his discoveries years ago. He found out that in a closed circuit a current is induced as often as a magnet is approached to this conductor or withdrawn from it, or as often as a current is closed or interrupted in the neighbourhood of the closed circuit, as soon as a *change in the intensity* of an electric or magnetic field takes place.

This discovery was the first step towards producing electricity by mechanical power—towards the dynamo, telephone, spark coil, and all the marvellous acquisitions of the last fifty years.

Origin of the Induced Currents.—If the two ends of a wire are connected with a sensitive galvanometer, and a magnet is approached to the wire, the needle of the galvanometer declines *as long as the magnet is approaching*, and returns to **0** if we cease to change the distance between wire and magnet. If we *withdraw* the magnet, the needle declines again, *but in the opposite direction.*

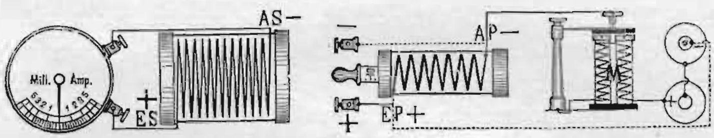


Fig. 11.

If in the neighbourhood of the closed conductor a second wire is drawn parallel to the first one, and the ends of this second wire are connected with a galvanic cell, the needle deflects the moment the circuit is closed, although there is no connection whatever between the two wires; but it returns to **0** immediately afterwards, and remains there, although the galvanic current continues to circulate in the second wire. If we diminish or interrupt the current, the needle deflects again, but in the *opposite direction.* This shows that the approaching and the withdrawing of a magnet, or the making and the breaking of a current in a conductor close by, induces currents in a closed circuit, which, however, are of very short duration only, and which pass in opposite directions.

Alternating Currents.—The currents induced by *closing* a galvanic current pass in the direction *opposite* to that of the inducing current; the currents induced by *breaking* the inducing current pass in the *same* direction as the inducing current. If we make and break the inducing current very often consecutively, we induce each time a momentary current in another conductor; but the directions of these induced currents keep changing, and for this reason we call them *alternating* currents, in contrast to those currents which keep their polarity in the same direction.

Wagner's Hammer.—Wagner's hammer (see diagram, page 32) is most frequently used for rapidly making and breaking the current. The current passes through the electro-magnet, through the hammer, the contact screw, and back to the battery; or else it can be made to pass from the contact screw through the inducing wire, and then back to the battery. As soon as this arrangement is connected with a cell, the electro-magnet becomes magnetic and attracts the hammer, which consequently leaves the platinum point of the contact screw. This, however, interrupts the current, the electro-magnet ceases to be magnetic, and a spring causes the hammer to fly back; as soon as it touches the platinum point again, the current is closed once more and the hammer attracted, and this play lasts as long as the apparatus is connected with a cell giving a current.

Iron Core.—The inducing effect of a current is considerably increased by letting it act simultaneously with a magnet, and this can be arranged easily if the primary wire is wound round an iron core. The iron core should consist

of a bundle of soft iron wires, as these take and lose magnetism much quicker than solid iron. In this way two powers act inducing in the same direction and at the same time, the making and breaking of the inducing current, and the sudden appearance and disappearance of a magnetic field.

E.M.F. of the Induced Current.—The E.M.F. of the induced current depends (1) On the number of turns of wire which a coil has; the more turns the higher the E.M.F. (2) On the strength of the inducing currents; the stronger the latter, the higher the E.M.F. of the induced currents. (3) On the presence or absence of an electro-magnet; its presence increases the E.M.F. of the induced current very materially. (4) On the suddenness of the break of the inducing current. Ultimately the E.M.F. of the secondary current depends on the distance between the secondary and primary coils.

Self-Induction. Extra Currents.—The wire through which the inducing current passes is called the *primary* wire, and the wire in which currents are induced is called the *secondary* wire; the induced current is called the *secondary* current. For various reasons we do not draw the primary and secondary wires in a straight line, but wind them in spirals on cylinders of ebonite, etc., which are made of such sizes that the primary coil can be pushed into the secondary coil. As soon as the primary current is closed, an electro-magnetic field appears, which induces a current not only in the secondary coil, but in the primary coil as well. This is called the "extra current," due to self-induction. If the primary current is closed, the extra current, too, has an opposite direction to the inducing current, and thereby *retards and weakens* the inducing current, and consequently the secondary current, too; but if the inducing current is interrupted, the extra current flows in the *same direction* as the inducing current, and *increases* thereby the latter current very considerably, and consequently the secondary current, too. The shocks which are induced by making and breaking the inducing current are, therefore, of very unequal strength; those induced by breaking the inducing current predominate very much, and the signs + and – which are near the terminals of some induction coils are intended to show the direction of the currents induced by *breaking* the inducing current. The signs would have no meaning if the currents induced by making and breaking the inducing current had an equal strength, as they follow one another in opposite directions.

Primary Currents.—If we connect one or two galvanic cells with a Wagner's hammer, which is provided with a small electro-magnet only, and connect the cells by means of two further wires with two electrodes, which we hold in our hands, we shall not feel the making or breaking of the current. But if the current has to pass a primary coil with several hundred turns of wire besides the Wagner's hammer, each breaking of the current gives us a decided shock, the strength of which, amongst other things, depends upon the number of turns of the coil; this shock is caused by the extra current. This is the *primary* current, which we obtain from medical induction apparatus; it is an *intermittent galvanic current*, very considerably increased by the extra current, but it is *not an alternating current*

Induced Current.—The strength of the induced current depends, too, on Ohm's law. If, for instance, an induced current has 70 volts, and the resistance of the secondary coil is 610 ohms, and the resistance of the patient 2,300 ohms, the strength of the current would be

$$\frac{70 \text{ volts}}{610 + 2{,}300 \text{ ohms}} = 0{\cdot}024 \text{ ampères} = 24 \text{ milliampères.}$$

The chemical action of faradic currents is small, principally on account of their very short duration, and moreover because they are alternating, so that each following impulse partly neutralises the effect of the preceding impulse. The physiological effect of these suddenly appearing and disappearing currents on the human body, however, is intense, the muscles contract each time the current is made, and much more so when it is broken; so that the muscles can be excited with these currents to a great extent.

Differences in the Effects produced by Primary and Secondary Currents.—The effect produced by the secondary current depends a great deal on the diameter of the wire which is used. Very fine wires (0·1 millimetre, or finer) produce a pricking local pain but not strong muscular contractions; if we increase the diameter of the wire, the contractions become more powerful; if the secondary coils are wound with thick wire they produce the same effects as a primary current, i.e., less local pain, but powerful contractions of the muscles near the electrodes, or even in the whole body. The primary, or the secondary current produced in a coil with thick wire, is frequently applied if the deeper lying organs, such as, for instance, the bowels, etc., are to be treated, whereas the secondary current produced by a coil with fine wire is chiefly used for the treatment of muscles and nerves which are near to the skin. This is the practical difference between primary and secondary currents. It is no doubt only due to the great difference in the resistance of the coils and in the E.M.F., but it is impossible to draw a sharp line between them, and to define accurately in what cases the one, and in what cases the other, should be applied. For the electric bath only the primary current, or a secondary coil with thick wire, can be used.

How to Regulate the Primary Currents.—The E.M.F. of the primary current can be regulated in different ways: the simplest method is to regulate the E.M.F. by pushing the iron core in and out. The primary current is weakest if the iron core is drawn out, and becomes stronger the more it is pushed in. Instead of drawing the iron core out, a damper in the shape of a brass tube can be slipped over it with the same effect. If the iron core is entirely covered with the tube, its inducing power ceases to act, but the E.M.F. increases the more the brass tube is withdrawn. The position of the secondary coil has *no* influence on the strength of the *primary* current.

How to Regulate the Secondary Current.—The secondary coil is generally constructed with a large number of turns of wire, about 1,000 to 5,000 turns, for in most cases it is desired to obtain a high E.M.F. The strength of the secondary current can be regulated in different ways. If the apparatus has a small primary coil, it is sufficient for all purposes of treatment to regulate

the strength of the secondary current, merely by pushing the iron core in and out, for a current which is hardly to be felt when the iron core is drawn out can be increased quite gradually to painful strength by pushing it home. The more complete coils are so arranged that the distance between the primary

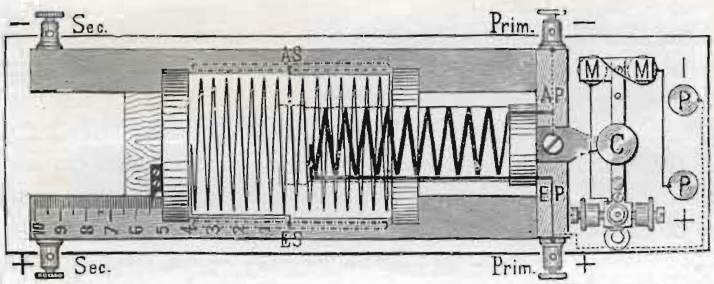


Fig. 12.

and secondary coil can be easily changed. In this case the secondary coil slides on a sledge, and can be pushed over the primary coil, or be drawn away from it, an arrangement which allows an exceedingly fine regulation of the current. These sledge coils are preferable for diagnostic and for physiological purposes.

Rapidity of Interruptions.—The Wagner hammer of an induction apparatus can be regulated within certain limits, so that the interruptions follow one another slower or quicker. The sooner the hammer meets the platinum point again after having been drawn away from the electro-magnet by the force of a spring, the sooner the current is closed and the hammer attracted again. The further we screw this contact screw home, the quicker will be the vibrations; but if we screw it too tightly, the hammer has no room for moving any more, and ceases to work. The more we unscrew the contact screw, the slower will the interruptions follow one another; but we must not unscrew it too far, as the hammer must make good contact with the platinum point in flying back, else it would also cease to vibrate. In order to make the interruptions even slower, the hammer can be lengthened with a bar, on which an aluminium ball can be raised or lowered. The longer this pendulum is, the slower are the interruptions. Slow interruptions produce more powerful and painful contractions than quick ones. If the number of interruptions is very great, anæsthesia can be produced, and special apparatus have been made for obtaining this result.

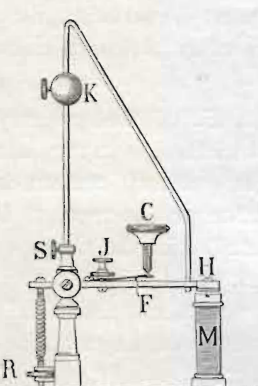


Fig. 13.

What are the most suitable Cells ?—Faradic batteries require a current of 0·3 to 0·8 ampères, and 1·5 to 3 volts. Leclanché cells, bichromate cells, accumulators, or the current from the main may be used. For all portable

batteries, the Leclanché dry cells are most convenient, and for this reason they have superseded all the other cells. Good cells of this kind are sufficiently constant; there is no glass to break, no fluid to spill and damage coil or clothes; and the repairs, which were formerly so frequent, have practically ceased since the introduction of good dry cells. Bichromate cells have still some advantages in out-of-the-way places like the Colonies, because they can so easily be re-charged. The continuous current from the main may be used if an incandescent lamp is inserted as resistance, and a shunt arranged across the interrupter. Further particulars of this will be found on subsequent pages.

Faults.—If an induction coil fails, you should see first whether the element is exhausted. If you are sure that the cell is all right and gives the necessary current, you should see whether the interrupter is in order. The interrupter is the most delicate part of the induction coil, and therefore you should be careful not to interfere with the contact screw if it is not strictly necessary; frequently apparatus which were in good order have been spoiled by playing with this screw. The interrupter does not always start of its own account, and has to be put in vibration by being slightly touched with the finger. The hammer should be arranged so that its distance from the electro-magnet is about the 16th part of an inch, and the platinum point of the contact screw should just touch it. If an interrupter has not the proper distance from the electro-magnet, it has to be carefully bent till it keeps the correct distance. The spark on the interrupter attracts dust, and the little platinum sheet should be cleaned occasionally with fine emery paper. Oil should on no account be allowed on the interrupter.

If the apparatus fails, although cell and interrupter are in order, *see whether the connecting cords* are in order. We should like to repeat here, that it is of no use to test an apparatus by touching the terminals or the connecting cords with two fingers. An apparatus can only be tested with well soaked and properly connected electrodes.

Faradimeters.—For more than twenty years there has been a desire for some method by means of which the faradic current can be measured like a continuous current. Galvanometers are not satisfactory for this purpose for two reasons: many of the instruments which are capable of measuring the alternating currents (for instance, the "hot wire" galvanometers) cannot yet be made so sensitive that they would indicate a few milliampères. The second, and more important reason, is that galvanometers cannot be used unless all the interrupters of the coils vibrate at a fairly rapid rate, because a galvanometer will register less if there are only 5 interruptions per second than if there are about 20 interruptions in the same time, in spite of the fact that the current may be of exactly the same strength in both cases.

In 1903, Dr. Leduc suggested to use a continuous current with an interrupter (or reverser) worked by an electric motor, for testing the reaction of muscles, and for treatment with the interrupted current. The interrupter or reverser is fixed on the axis of the motor; it is in the circuit of a galvanic battery, and a milliampère meter is also in the circuit. By means of the latter the current flowing through the patient can be measured while the interrupter

is at rest; when it is started, the galvanometer will indicate less, and the difference between the two readings can be used to find out the duration of the current. If the galvanometer indicates, for instance, one-fifth of its former reading, it shows that the current is closed for one-fifth, and "off" for four-fifths of the time of a period or revolution. The proportion between the time it is "on" to the time it is "off" can be varied by altering the position of one of the two brushes.

It has been proved that more powerful contractions of muscles, with less pain, are obtained with short contacts and long intervals with no current, i.e., if the brushes are so adjusted that the time during which the current is closed is only about one-tenth of the time during which the current is "off." The number of periods or interruptions per minute can be adjusted by altering the speed of the motor. The E.M.F. used can be regulated by varying the number of cells in the circuit. By means of such apparatus, anæsthesia can also be produced, as has recently been shown by Dr. Leduc. More particulars will be found in "Medical Electrology and Radiology," October, 1904, and in the "Archives of the Röntgen Ray," May, 1912, pages 464–469.

These phenomena have been further investigated by Dr. Lewis Jones, who speaks highly of the advantages of such currents over those of a faradic coil.

APPARATUS FOR USING THE CURRENT FROM THE MAIN.

The electric current for lighting houses is now available in all towns, and even in many rural districts. It is obviously much more convenient to obtain a current of perfect constancy delivered into one's house ready made, by merely turning a switch, than to have to generate it in primary batteries or to store it in accumulators. The transformers or rheostats controlling the current require no charging with corrosive liquids; most of them are not even subject to any wear and tear, and in consequence they are not liable to get out of order. There are already over 3,000 of such switchboards for medical purposes in daily use, some of them since twenty-one years, and the advantages are so great that I need not waste any more words about this.

There exist two kinds of current which may be used for lighting houses, viz., the continuous or the alternating current.

Continuous Current.—In some towns the continuous or low tension current is supplied. The E.M.F. used in the mains in the street is not higher than that which is being used in the houses, and varies from 100 to 250 volts in different towns. Heavy copper cables are required to distribute such a low tension current, and it is therefore suitable only for thickly populated districts, and for comparatively short distances, not exceeding one and a half miles.

The continuous current is suitable for every purpose for which electricity may be employed in medicine or surgery: as galvanisation, electrolysis, and faradisation; cautery, surgical lamps, and motors; X-ray and high-frequency apparatus, lamps for treating lupus, electro-magnets, charging accumulators, etc.

Alternating Current.—In other towns, and in many rural districts, the alternating current is being supplied. This current changes its direction from 50 to 100 times every second. The number of volts and ampères of such an alternating current can easily be raised or lowered; a high voltage, from 2,000 to 10,000 volts, is being used in the mains, and on entering a house this high tension is transformed down to 200 or 100 volts and a greater number of ampères, so that it can be used for incandescent lamps, etc. The advantage of this system for the electric lighting companies lies in the fact that the copper cables used for the mains have to be only one-tenth to one-hundredth part of the thickness which would be required for the distribution of the same quantity of current at low voltage.

The number of ampères which a cable can carry without becoming hot is limited, and ought not to exceed 1,000 ampères per square inch (cross section) of copper. The number of volts, however, can be raised as far as the safety of the insulation will permit; as many as 30,000 volts have already been used in wires suspended on porcelain insulators on telegraph poles, and sent over a distance of more than 100 miles. A copper cable with a cross section of one square inch can carry only 100,000 watts with 100 volts, but 5,000,000 watts with 5,000 volts. The clear gain to the electric light company is not nearly as great as these figures imply, because for cables intended for 5,000 volts a much better insulation is necessary than for cables intended for 200 volts only; moreover, accumulators cannot be used with the alternating current, and the engines have therefore to run all day long, and ultimately there is some constant loss in all the transformers fixed in the consumers' houses, as long as no current is being used in the houses. Nevertheless, the alternating current must be used whenever the current has to be sent over long distances, to reduce the heavy cost of the copper cables.

The alternating current is very convenient for cautery, surgical lamps, motors, and for treatment with sinusoidal currents; it can be used for producing X-rays and high frequency currents, but for charging accumulators it has to be made unidirectional. It cannot be used for galvanisation or for electro-magnets.

For the continuous as well as for the alternating current, it is necessary to employ a rheostat or a transformer of some kind, to control the current's strength, or to reduce the voltage, etc., in order to protect the patient or the apparatus from overdoses or dangerous currents. I was the first engineer who began making such apparatus in my workshop in London in 1890. They vary very much according to the type (continuous or alternating) and the voltage of the current, and according to the purpose for which they are wanted (galvanisation or cautery, etc.), and will be explained more fully in the following pages.

Continuous Current Installations.—For galvanisation and electrolysis we require currents ranging from a fraction of a milliampère up to 50, and in a few exceptional cases even 200 milliampères. There are two ways by means of which a 100-volt current can be reduced so as to produce only a few milliampères through the resistance of the patient's body: either an artificial resistance has to be inserted in the circuit "in series" with the patient, or else a shunt circuit has to be arranged.

In the former case we would require a resistance of 100,000 ohms to reduce a 100-volt current to 0·001 ampère (= 1 milliampère). There is no difficulty in obtaining such high resistances, for instance, with graphite rheostats; they were used to some extent in the earliest attempts to utilize these currents, but the method of placing the patient "in series" with the dynamo has some defects. Even a weak current of, say, 2 milliampères, which would not be felt at all if produced by a battery of a few volts only, causes a peculiar burning sensation. With 200 volts it is worse. In consequence of this we tried the other method, by placing the patient's body in a shunt circuit. This system has proved such a complete success that all switchboards for galvanisation and electrolysis are now arranged on this principle.

Shunt.—Shunt circuits are used not only for galvanisation and electrolysis, but for surgical lamps, X-ray apparatus, arc lamps, etc., as well. I will try to explain the principle of this shunt connection, which is the same in all apparatus.

If a current passes through a resistance A B, and we connect another conductor with two points of this circuit, say, at C and B, a current will circulate in this second conductor as well, and the E.M.F. in this shunt circuit C X B is in the same proportion to the E.M.F. between A and B as the resistance between C B is to that between A B. If, for instance, the E.M.F. between

Fig. 14.

A and B is 100 volts, and the resistance in C B one half of that in A B, then the E.M.F. in C X B will be 50 volts, or it would be 10 volts if the resistance in C B were only one-tenth of that in A B. According to the spot where C is connected we can obtain for the shunt circuit any E.M.F. we like, from 0 upwards; only, of course, it cannot exceed the E.M.F. existing between A and B, and if the apparatus is so constructed that C is movable, the E.M.F. in C X B can easily be varied by moving the point C.

With this arrangement we need not employ more volts than are necessary for obtaining the desired strength of current in X. X represents either a patient, a spark coil, or a lamp, etc.

The strength of current in the shunt circuit depends on the E.M.F. and the proportion of the resistance in C X B to that in C B. If these resistances

were equal, the current would have an equal strength in both loops; if the resistance in C X B is greater than that in C B, more current will pass through C B than through C X B.

If the current in C X B is interrupted near X there will be no spark, because the current in A B has not been broken, only a part of it has been shunted to another branch: moreover, it has been proved that with such a connection a current from a dynamo can be endured just as easily as a similar current from a battery; the only disadvantage is, that the part of the current passing through C B is wasted. The currents employed for galvanisation, faradisation, surgical lamps, etc., are so weak that this waste is not worth mentioning, it will scarcely amount to one shilling during a whole year; for cautery or spark coils the loss is greater. However, the electricity generated by dynamos is much cheaper than that produced by batteries; we shall refer to the actual cost later on under rheostats for spark coils.

Switchboard for Galvanisation and Electrolysis.—In order to control the currents from the main for galvanisation and electrolysis, we use a special shunt rheostat or volt selector (see No. 327). It consists of a slate core, round which about 500 turns of a fine platinoid wire are wound; the single turns are quite close together, but insulated from one another. The total resistance is about 400 ohms. The sliding spring shown in the diagram Fig. 15 corresponds with the point C in Fig. 14. An incandescent lamp is also inserted in the circuit, partly as a safety resistance, to protect the patient against an overdose, partly to increase the total resistance, so that the fine wire cannot be overheated. The lamp burns with a dull red light as long as the switch is turned on, whether the electrodes are connected or not, and thus acts as a signal to turn the current off when the application is over.

If the sliding spring is on the right-hand side near B, the E.M.F. between the terminals leading to the patient is only a small fraction of a volt. As we move the spring towards the left, the E.M.F. available at the terminals will increase, but only very gradually, on account of the large number of turns; the increase amounts only to about 0·15 volt per turn of wire. When the spring C is on the left-hand side near A, the maximum number of volts has been reached. With a 100-volt supply and a 16 c.p. lamp in circuit, this maximum will be about 65 volts. Such a rheostat allows an exceedingly fine graduation of the current's strength, which can be increased from a small

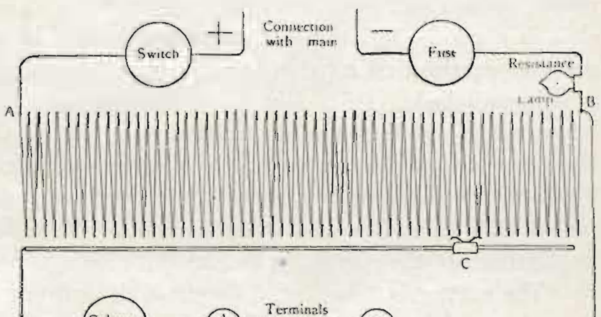


Fig. 15.

fraction of a milliampère up to the full strength we wish to employ, without the patient feeling any jumps at all. The increase or decrease is much more gradual than that which we obtain with a battery and collector; the latter cannot add less than one cell (= 1·5 volt) at a time, and this may be felt as a shock if the current is applied to sensitive parts like the head.

The diagram (Fig. 15) shows a galvanometer, which should always be employed with these apparatus. If batteries are used, the number of cells is an unreliable control, but still some sort of a guide to estimate the current; but with a 100-volt current without a galvanometer one works absolutely in the dark.

There are yet other accessories which may be inserted in the shunt circuit, as current reversers, etc., but as they do not differ from those used for batteries, we refer the reader to pages 11–13.

Is it absolutely Safe to use the Currents from Dynamos for Galvanisation ?— With a shunt rheostat and a lamp arranged as described, it is not possible that the patient may receive an overdose; of course the current may be applied by mistake, while the spring of the rheostat is at "strong" instead of at "weak," just as easily as this can happen while the current collector of a battery is full on; the result in both cases will be an unpleasant, but not a dangerous shock. With underground cables it is impossible that the E.M.F. of a continuous current may suddenly rise to dangerous proportions.

There is, however, in all installations a certain amount of leakage, i.e., escape of electricity to earth in consequence of defective insulation. In many districts, where the so-called three-wire system is being used, one pole of the dynamo is intentionally connected with the earth. If, for instance, the + pole of the dynamo is in contact with the earth, a patient who is in good electrical contact with the earth may receive an unexpected shock when an electrode is applied, even if the sliding spring is close to B, if this electrode happens to be connected with the negative pole of the dynamo. But we never hear of such shocks, and the reason is, no doubt, that patients are nearly always well insulated from earth. A *dry* wooden floor, carpet, linoleum, etc., is a good insulation for these purposes. It is not likely to happen in private practice that a patient will be on a damp stone floor * while the current is being applied. In a few cases doctors have received unpleasant shocks when, while holding an electrode in one hand, they have attempted with the other to open a water tap to moisten the electrodes. *It must be made a rule not to touch gas or water pipes on any account, as long as one hand is in contact with the switchboard or an electrode.* There is really no danger in *local* applications of the current as long as this rule is adhered to.

The matter is, however, different if the current is to be applied in a bath. A patient might receive even a fatal shock if the necessary precautions are

* The stone floor of operating theatres in hospitals is an insufficient insulation; frequently the difficulty can be overcome by placing a dry linoleum or indiarubber mat under patient and operator. In some large hospitals it will be safer to transform the current before it is being used, because it cannot be avoided that persons may have to handle these apparatus who are quite unacquainted with them.

neglected.* The water in a bath tub, even if the latter is made of porcelain, is in excellent contact with the earth through the waste pipes, etc., which are of metal. If the current is intended to be applied in a bath, it is necessary to insulate the water by replacing the metallic waste pipes by others made of earthenware for a considerable distance; by enclosing the inlet pipes and taps in wooden cases, so that a patient cannot possibly touch them, and by using a bath tub made of porcelain or wood. A current reverser should not be on the switchboard, and this should be so connected that B of our diagram is connected with the earthed pole. If there is any doubt at all, or if the current is to be used for an electric bath in a hospital, hydro, etc., it will be necessary to *transform* the current by means of an electric motor driving a small dynamo (see No. 1790); this is an absolute protection against any danger.

The above remarks apply to the ordinary water bath; if the current is applied in small local baths to feet or arms, as, for instance, in the so-called Schnee's 4-cell bath, there is no danger at all, because for these purposes small earthenware or glass vessels are usually employed, which are not connected with the earth by waste pipes.

Apparatus for Faradisation.—A coil for faradisation is frequently connected with the above described apparatus for galvanisation. A current of about 0·5 ampère is required to work these coils, and the easiest way of obtaining it is by inserting an incandescent lamp in the circuit as a resistance. A shunt resistance must be arranged parallel to the interrupter to prevent sparking, which would destroy the platinum contacts.

Apparatus for Cautery.—For galvanisation and electrolysis the maximum current required does not exceed 0·3 ampère; the most frequently used cautery burners, however, consume 18 ampères. About 200 times as much current is, therefore, wanted for cautery as for galvanisation, and since the requirements for cautery are entirely different from those for galvanisation, the same apparatus cannot be used for both purposes.

It is not possible to attach a cautery burner directly to the main, as it would be fused instantly, but the current may be used if either :—

(1) The current is transformed into a lower voltage.

(2) A suitable rheostat is inserted.

(3) A few accumulator cells are charged.

Transformers.—A continuous current can be transformed into a lower voltage either by means of a motor, or else by changing the continuous current first into an intermittent current by means of an interrupter. The voltage can then be reduced by a transformer similar to those used for alternating currents.

In either case the primary current required does not exceed 1·5 ampères with 200 volts, and the ordinary size cables used in a room are sufficient;

* A fatal accident which happened in London in Nov., 1912 proves that this warning, which appeared in all editions of our Catalogue since 1905, is only too well founded.

these transformers can, therefore, be connected with any existing wall-plug or lamp-holder. They consume less than two pennyworth of electricity per hour.

Motor Transformers consist of a motor, which is driven by the current from the main. This motor may either be combined with a small dynamo which supplies a continuous current of low voltage, or the motor may be used to convert the continuous into an alternating current. In the first case, the motors are provided with a second winding on the armature; in consequence of this the drum and the whole motor must be comparatively large. The second winding spins round in the magnetic field, and according to the number of turns and the diameter of the wire used, currents of another voltage and ampèrage are induced in it, which are taken off by brushes at a separate collector.

In the second case, the ends of the winding of the armature are connected with two separate collector rings, from which an alternating current is taken off. The armature need then not be larger, but this current has yet to be transformed by means of a small alternating current transformer, so that the volts and ampères are suitable for cautery burners.

These motor transformers have an efficiency of 60 per cent, i.e., a current of 200 volts and 2 ampères may be transformed into a current of 10 to 12 volts and about 20 ampères. They require very little attention; the bearings must be oiled about once a month, and the resistance contained in the base of the motors must be inserted before the switch is turned on to start it. The speed is then increased by diminishing the resistance in the circuit, till the desired degree of incandescence is obtained in the cautery burner. If these few points are attended to, the motor transformers will remain absolutely reliable for many years without requiring repairs.

As the current is being transformed, it is impossible that the patient or operator can receive any shock, even if they touch water or gas pipes while being in contact with the instrument.

These motor transformers have the great advantage that, besides for cautery and surgical lamps, they can be used equally well for all surgical operations requiring drills, burrs, saws, trephines, etc. They can be used for massage, rapid vibration, or percussion treatment, for working the air pumps used for pneumatic massage of the ear, or for vaporizing drugs. If they transform into an alternating current, this may be used for applying sinusoidal currents; if they transform into a continuous current of lower voltage, they can also be used for charging a few accumulators.

Interrupter Transformers.—The continuous current can be converted into a pulsating current by means of an interrupter,* and the intermittent current thus obtained can be converted into a current of fewer volts but more ampères by means of a transformer similar to those used for transforming

* An electrolytical interrupter may be used, but it consumes more current and makes more noise than a mechanical interrupter.

alternating currents. The efficiency of these interrupter transformers is nearly as great as that of the motor transformers, and amounts to about 45 per cent. The interrupter transformers are cheaper than the motor transformers. On the other hand, they are useful only for cautery; other apparatus, like a rheostat for surgical lamps or for galvanisation, can be added, but the transformers cannot be used for drills or massage, like the motor transformers.

Rheostats for Cautery have been superseded by the more efficient transformers, and are not used any more since the voltage of the electric supplies has been raised almost everywhere to 200 or more volts.

Accumulators can be charged and used for heating the cautery burners. They can be connected for charging with almost any wall-plug or lamp-holder, but a resistance has to be inserted in the circuit in order to protect the plates of the accumulator from too heavy a current. Incandescent lamps are usually chosen as resistance; the candle-power of the lamps to be used depends on the capacity of the accumulators and the number of volts of the supply. If the light of these lamps is not turned to any useful purpose, the efficiency is not great, because about nine-tenths of the current are wasted in making the carbon filament of the lamp incandescent. It is, however, frequently possible to arrange it so that the accumulator is inserted in the circuit of lamps, the light of which is used for illuminating a hall, dining-room, etc., and under such circumstances the charging would practically cost nothing, and, what is more important, the accumulators would be charged at frequent intervals, and would thus be kept in good condition for the longest possible time. Accumulators have also the advantage that they can be taken away and used in houses where the current from the main is not available.

Accumulators require some supervision. Care must be taken that the poles are connected correctly, and that they are not left too long without being re-charged. For fuller information about the charging and treatment of accumulators, see pages 25-27.

Surgical Lamps cannot be connected directly with the main. The glass bulbs of lamps used for examining the various cavities of the human body must be small, and carbon filaments capable of standing currents of 100 volts must necessarily be long in order to have a sufficient resistance; there would be no room for them in these small bulbs.

The current from the main can be reduced either by means of a transformer—nearly all the transformers made for cautery are so arranged that they can also be used for surgical lamps—or by means of a rheostat. An incandescent lamp serves usually as the resistance. If the resistance lamp is connected with a small variable rheostat, and the surgical lamp is placed in a shunt circuit to this rheostat, there will be no spark on breaking the shunt circuit, and the amount of light is perfectly under control. Any size lamp, from the smallest which is to be introduced through the male urethra, can be used with such a rheostat. Rheostats on this principle can be made in various forms, and can be used equally well on the continuous or the alternating current.

For working **Spark Coils** for X-rays or high frequency currents, the continuous current from the main is the most convenient, and, at the same time, the most efficient source of supply. Particulars will be found under X rays.

Arc Lamps for Treating Lupus, etc., require a continuous current of not less than 50, and not more than 65 volts, and from 10 up to 60 ampères, according to the size and the candle-power of the lamps. If the current from the main has 100 volts, rheostats are most frequently used to reduce it to 60 volts ; if the E.M.F. is 200 or more volts, a rheostat may be used, provided that not more than 25 ampères are required ; but if the lamp is wanted for many hours every day, or if currents of more than 25 ampères are necessary, a motor transformer has to be employed instead of a rheostat.

Some microbes are killed by the light itself ; others are killed by the inflammation following the prolonged application of a powerful light. In any case, it is necessary to have the light as powerful as possible, and lenses are invariably used with the arc lamps to concentrate the light of the lamp on the spot which is to be treated. The heat of such a powerful light is very great. The lenses through which it passes would crack, and the patient's skin would be burned, unless precautions were adopted to carry off the heat. The simplest and most efficient remedy is to keep a stream of water circulating between the lenses. This plan is adopted in the optical part of all the arc lamps, whether they are large or small. A stream of water also passes through the compressor, to be mentioned later on. Distilled water has to be used, as ordinary water would absorb the ultra-violet light.

As it is the ultra-violet part of the light which produces the changes, the lenses used have to be made of quartz, which is much more transparent to these chemical rays than glass.

Blood is opaque to the light rays, and in order to reach deeper-lying tissues the parts have to be made anæmic, which can be done either by pressure alone (by pressing a rock-crystal lens firmly against the part to be treated), or by pressure combined with cold (by using a piece of ice as compressor).

Mercury Vapour Lamps.—The mercury vapour lamps have been found to be very rich in rays of a wave length below 400 $\mu\mu$, usually called the ultra-violet rays, and they are therefore suitable for the treatment known under Prof. Finsen's name, provided that the tubes in which the light is generated are pervious to the ultra-violet rays.

Ordinary glass is quite unsuitable, but in the glass-works of Dr. Schott, in Jena, a new kind of glass has been discovered which is pervious to the ultra-violet rays. Two or three tubes of this glass, 20 to 36 ins. long and about 1 in. diameter, are suspended on a stand with a reflector behind. The tubes carry platinum wires with carbon electrodes inside at either end, and contain a certain quantity of mercury. They are connected with a continuous current supply (alternating current cannot be used) of 100 to 250 volts in such a manner that the negative pole is connected with the lower end, which remains covered by the mercury after the light has been started. The tubes are tilted till the mercury flows over and connects both poles for a moment ; as soon as the mercury thread breaks some-

where, the mercury vapour is generated by the current, the reflector is brought back to a vertical or inclined position, when a steady light of a peculiar green colour is obtained. The light thus generated is cheaper than that of the electric incandescent lamps with carbon filaments—the latter require about 4 watts per candle power, the mercury vapour lamps only about 0·5 watt.

The rays emitted by the uviol lamps have a deadly effect on small insects; a fly dies within one minute if brought near such a lamp, and bacteria are killed by it as they are by sunlight. The skin of patients exposed to this light becomes bronzed, and if continued long enough the same inflammations and reactions are produced which are obtained with the powerful Finsen or Finsen-Reyn lamps, by burns with X rays, or by sun-burns on the high Alps. The operators have to wear spectacles to protect their eyes.

The light is not only suitable for treating lupus, eczema, etc., but can also be used for light baths for stimulating the skin.

For **Electric Light Baths** it is immaterial whether the continuous or the alternating current is available, as either kind can be used equally well. The candle-power employed in the baths is not strong enough to kill microbes, but the light has a stimulating effect. It opens the pores of the skin, and the heat given off by the incandescent lamps causes strong perspiration, similar to that produced in a Turkish bath. The light baths are, however, more pleasant than the Turkish baths, because the heat is dry and easily under control, and because the patient can breathe air of ordinary temperature, and in consequence heart and lungs are not affected as they are in a Turkish bath.

Electro-Magnets.—The small hand magnets, as well as the giant magnets like Haab's, required to remove pieces of steel or iron from the eye, can be used with the continuous current only. The diameter of the copper wire and the number of turns must be adapted to the voltage of the supply; a magnet wound for 100 volts has fewer turns of a stouter wire than a magnet wound for 250 volts.

ALTERNATING CURRENT.

The alternating current is superior to the continuous current only for cautery; it is equal in efficiency to the continuous current for all illuminating instruments, light baths, motors, etc., but it is less convenient for almost all other purposes, and in some cases—for instance, for galvanisation or for charging accumulators—it cannot be used unless it has first been converted into a continuous current.

Transformers.—Alternating currents can easily be transformed by induction, so that, for instance, 2,000 volts and 1 ampère can be converted into 100 volts and 20 ampères. Transformers are used in all houses where an alternating current is laid on, to transform the high tension current so that it can be used for incandescent lamps.

The transformers are a kind of induction coil. An insulated primary wire is wound round a bundle of soft thin iron sheets, which are insulated from one another; above this primary is wound the secondary wire, in which currents are induced by the alternating current circulating in the primary coil, and by the magnetism of the iron core. The secondary coil must have fewer turns than the primary one if the number of volts is to be reduced, or it must have more turns of a finer wire if the number of volts has to be raised.

Transformers for Cautery and Surgical Lamps.—For this purpose 100 volts and about 2 ampères are converted into about 10 volts and 19 ampères. If we insert a variable small rheostat in the secondary circuit, we can adapt the number of ampères to either small or large cautery burners. In most cases there is another secondary coil of medium-sized wire on these surgical transformers, giving currents of about 15 volts and 2 ampères; with the help of another small rheostat this can be used for surgical lamps. The efficiency and simplicity of these instruments surpasses that of the best continuous current transformers, or of any other source of electricity which may be used for cautery.

Charging Accumulators.—The alternating current has to be made unidirectional before it can be used for charging accumulators. It can be done in three ways: (1) by means of a synchronous rectifier; (2) with the help of aluminium cells (electrolytic rectifier); or (3) with a motor transformer.

In Synchronous Rectifiers a polarised relay is being used. An electro-magnet is connected with the alternating current; it therefore changes its polarity as frequently as the phases of the alternating current change. A permanent steel magnet is fixed like a Wagner's hammer above the electro-magnet; it is attracted by the electro-magnet while the latter has an opposite polarity, and is repelled while it has the same polarity, and in consequence the steel magnet vibrates synchronously with the alternating current dynamo. These movements can be used to close the circuit through the accumulators which are to be charged for a certain time, while the direction of the current is correct and the E.M.F. sufficiently high, and to break this circuit while the alternating current flows in the wrong direction. I have used one of these rectifiers for about eighteen months almost daily (till my supply was changed to the continuous current) for charging accumulators, and during this time it has never gone wrong or given any trouble; if properly adjusted there is no sparking at all.

Aluminium Cells.—A pulsating unidirectional current can also be obtained with the help of aluminium cells. These cells consist of a large indifferent electrode, and an active electrode of aluminium. The cells are charged with a solution of ammonium phosphate.

Aluminium has the peculiarity that it allows a current to pass freely while it is anode, but when it turns cathode it polarises rapidly, and offers so high a resistance that a current of less than 20 volts cannot pass. An arrangement of this kind is simpler than the mechanical rectifier previously described, but in actual working the aluminium cells have up to now given

some trouble. If they are used continuously for a considerable time, they become hot and the polarisation ceases; moreover, crystals form, and the cells have to be cleaned and scraped thoroughly at fairly frequent intervals. This is, no doubt, the reason why they have not come more into use.

Finally the alternating current can be converted into a continuous current by means of a *Motor Transformer* (see No. 1780). The installation of such a transformer is a little more expensive than that of a rectifier, but it gives no trouble, and the voltage of the continuous current dynamo can be adapted to the number of accumulators to be charged.

Sinusoidal Currents can be applied with the alternating current from the main. Particulars will be found under Sinusoidal Currents on page 49.

The alternating current cannot be used for galvanisation, electrolysis, for the large arc lamps for treating lupus, for electro-magnets required for removing pieces of steel, etc.; but, with the exception of galvanisation and electrolysis, it will be found more convenient and economical to generate the required continuous current in a dynamo for which an alternating current motor serves as the motive power. This is more convenient than a gas or oil engine, and batteries are out of the question for heavy currents. Motors and dynamos, and the combination of them, are explained in a special chapter (see below), and the motor transformers will be found under Nos. 1780–1793.

For galvanisation and electrolysis very weak currents only are required, and for these purposes it is certainly cheaper to use a battery than to use a motor transformer. Good Leclanché cells will give the necessary current with average use for fully two years without requiring re-charging, and the batteries are cheaper to buy and simpler to manage and maintain than a motor transformer, for which a special switchboard would also be wanted to regulate, measure, and reverse the current.

In those cases, however, where a motor transformer exists already (in many hospitals, for instance) for converting the alternating into a continuous current for spark coils or arc lamps, etc., it can of course be used also for galvanisation and electrolysis, if a suitable switchboard is added to control the current.

DYNAMOS, MOTORS, MOTOR TRANSFORMERS.

Electric Motors and Motor Transformers are used so extensively for various medical purposes, that a short explanation of them may be of interest to some of our readers.

A **Dynamo** consists of an electro-magnet, between the two poles of which is an armature which can turn round its axis. The armature consists of iron round which a coil of insulated copper wire is wound. The ends of this copper wire are connected either with two separate copper rings fixed on (but insulated from) the axis, or with a collector ring consisting of many segments. Collecting brushes press against the rings, and if the brushes are connected by a conductor, an external circuit is established.

The illustration gives a diagram of an alternating current dynamo. Of the electro-magnet only the poles N and S are shown. The armature is represented by one stout coil of wire a, b, c, d ; the ends of this wire are connected with the rings C and C1, which are insulated from one another, and against these rings press the brushes B and B1. The dotted lines from B *via* E to B1 represent the external circuit.

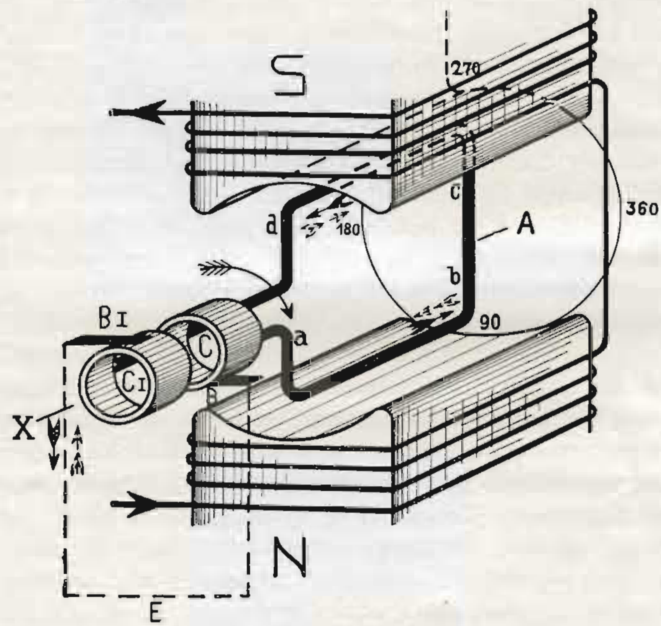


Fig. 16.

If the armature is driven round the axis A X by mechanical power, its position to the poles of the magnet will vary constantly ; a, b will alternately move over the north pole of the electro-magnet, as shown in the illustration ; after it has made half a turn it will move past the south pole. While a, b approaches the north pole, c, d is approaching the south pole, and an E.M.F. of opposite polarity is induced in each half of the armature (see page 29 about induction), as indicated by the black arrows. After the coil has made half a revolution, a, b comes near the south pole, the position of the armature to the poles of the magnet is reversed, the E.M.F. induced has now the opposite polarity, and the current is flowing in the direction of the dotted arrows.

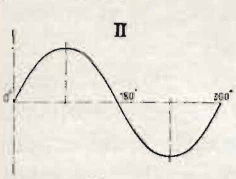


Fig. 17.

A current produced by such a dynamo describes curves as shown in illustration. While the coil of wire is in a horizontal position (connecting 360 with 180) there is no current ; while a, b approaches the north pole the current rises till the coil of wire has reached the vertical position shown in the diagram. When it moves farther on towards 180 the current diminishes, is 0 again when it has reached 180, increases then in opposite direction till it has reached 270, and falls afterwards again till it reaches

360. If the armature has made such a complete revolution from 0 to 360, we call it a "period"; when it has made half a turn only, from 0 to 180, we call it a "phase." If an incandescent lamp is in the external circuit, the light will appear steady as soon as the armature moves with a sufficient speed, *i.e.*, when it has not less than about 40 periods per second.

The annexed diagram (Fig. 18) shows quite a similar arrangement, only the copper ring is different. Instead of being connected with *two complete, separate* rings, the ends of the wire are attached to *two segments* (C and C1) *of one ring*, which are insulated from one another. When a, b is approaching N, the brush B is in contact with C, but when a, b is approaching S, the collector ring has also moved, and has brought B in contact with C1. In consequence of this the current in the external circuit *retains the same direction*, in spite of the fact that the polarity of the current in the armature changes, and a dynamo provided with such a commutator is called a continuous current dynamo.

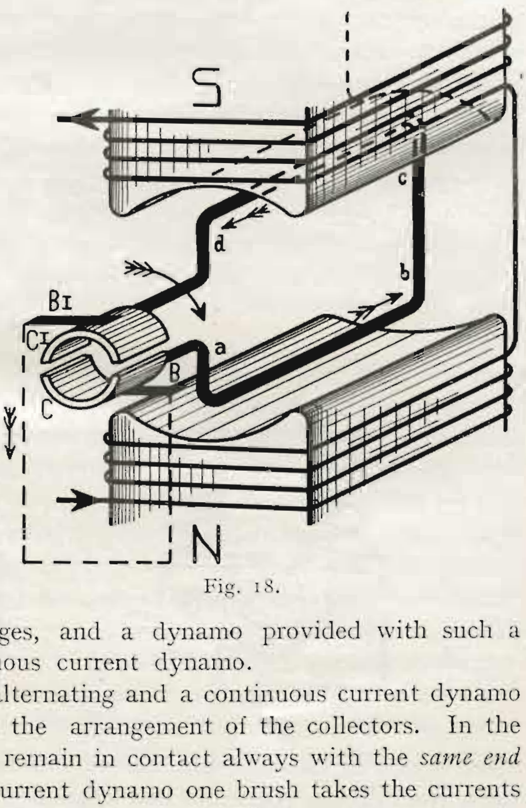


Fig. 18.

The difference between an alternating and a continuous current dynamo is not great—it consists only in the arrangement of the collectors. In the alternating dynamo the brushes remain in contact always with the *same end of the wire*; in the continuous current dynamo one brush takes the currents of the coils while they approach the north pole, the other brush receives the impulses while the coils approach the south pole. One and the same dynamo may even serve to produce both types of current if it is fitted with two separate rings from which the alternating current can be taken off, and, in addition, with a commutating collector from which the continuous current can be taken off. This is made use of in some transformers, to be described later on.

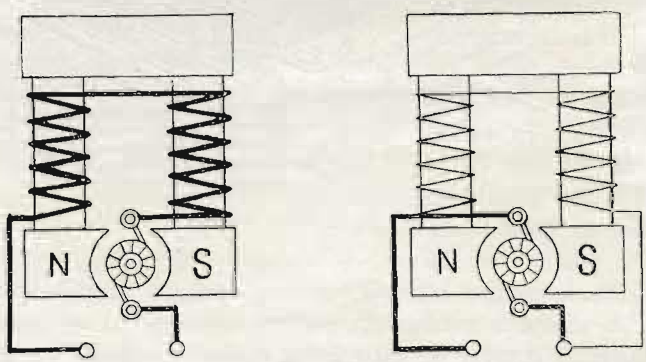
Practically there is never one coil of wire only, as shown in the two diagrams. The armature of a dynamo consists of a ring of iron wire, or thin discs of soft iron, and the whole circumference is wound with a continuous coil of wire. The E.M.F. induced in the upper half has the opposite polarity of that induced in the lower half. There is, therefore, no current flowing in the armature as long as the external circuit is open; when it is closed the current is discharging through the brushes and the external circuit.

A continuous current dynamo in no way differs from a continuous current

FARADISATION, GALVANISATION, E
CAUTERY, SURGIC LAMPS, MOTORS, E
from Main. LIGHT THERAP

motor—the same machine can serve either purpose.* If it is to be used as a dynamo, the armature has to be driven round by mechanical power, and currents are induced in consequence which are available in the external circuit to produce light, etc. If we wish to use it as a motor, we send a current through it which produces magnetism. Two opposite parts of the armature are made magnetic and attracted by the poles of the electro-magnet. As soon as the armature has moved a little, the collector, which moves simultaneously, sends the current through the next coil. In this manner one part of the armature is made magnetic after the other in regular, rapid succession. It revolves in consequence, and thus mechanical power is produced, which can be taken off a pulley fixed on the end of the axis.

"Series" or "Shunt" wound Dynamos or Motors.—The current which is induced in the armature does not pass only into the external circuit, it is also used for exciting the electro-magnet of the dynamo. If it passes from a brush round the magnets, then through the external circuit and back to the



a Fig. 19. *b*

other brush, as shown in Fig. 19 (*a*), the dynamo is wound "in series." If the current divides itself into two loops, i.e., a weaker current passing from a brush round the magnets and back to the second brush, and the stronger current flowing through the external circuit only, as shown in Fig. 19 (*b*), there are two separate circuits connected parallel to one another, and we say that such a dynamo is "shunt" wound. The latter type has the advantage that the magnetic field retains the same intensity whether the dynamo or motor has to do hard work or whether they run empty, and the E.M.F. or the number of revolutions are not influenced thereby. Most dynamos, and all good motors for surgical purposes and for motor transformers, are therefore "shunt" wound. "Series" wound motors are universally used for traction purposes; in electric carriages, etc., they have special advantages for this work.

Rheostats for Motors.—With all motors it is essential that a rheostat should be used. It is necessary in order to protect the motor from damage

*There is a considerable difference in the construction of an alternating current dynamo and an alternating current motor. Some of the latter have not even a collector.

in starting, and it is required to control the speed of the motor. As long as the armature does not revolve, there is great danger that it will be damaged if the full current is switched on. This is due to the fact that a considerable E.M.F. is produced in the armature as soon as it revolves in the magnetic field, and the polarity of this E.M.F. is *opposed* to that of the current driving the motor. It acts, therefore, as a powerful resistance to this current, and weakens it, but this resistance is absent as long as the armature does not revolve, and in consequence an artificial resistance has to be substituted. This is necessary for all motors, to protect them from an overdose. As soon as the armature has started, this artificial resistance may be reduced or switched off. Many motors are damaged because this necessary precaution is forgotten. The same rheostats help to regulate the speed of the motors, from the maximum of about 2,400 revolutions per minute down to a few hundred. The amount of resistance in the circuit can be increased or diminished by altering the position of a crank.

The bearings of a motor or dynamo must not be allowed to run dry; they have to be oiled from time to time.

Motor Transformers.—If a motor driven by the current from the main is coupled with a dynamo, we can produce currents of another type, or another voltage or ampèrage, according to the dynamo chosen, and call such a combination a motor transformer. They are used for a great variety of purposes; in some cases an existing alternating current has to be converted into a continuous current, because the latter is better for a spark coil or an arc lamp for treating lupus, or an electro-magnet, etc. In other cases an existing continuous current may have to be converted into an alternating current to obtain sinusoidal currents, or for transformers. Ultimately, the voltage of a continuous current may have to be reduced to make it suitable for cautery burners, arc lamps, for charging accumulators; or else the current may have to be transformed as a measure of precaution, to make the current applied in a bath independent of the main and of leakages, to avoid all possibility of shocks.

Particulars and illustrations of motor transformers for these various purposes will be found under Nos. 1780–1793.

Motor Transformers for Sinusoidal Currents.—Before concluding this chapter, I have yet to mention one particular motor transformer which is being

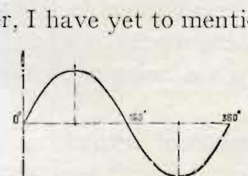


Fig. 20.

Fig. 21.

used to produce the so-called sinusoidal currents. This word has been invented to describe a wave-like alternating current, such as is produced by an alternating current dynamo, and to distinguish such a current from the irregular, jerky alternating current produced by a faradic coil. The two illustrations show

the curves of a sinusoidal current, and the curve of the secondary current of a faradic coil. The latter type produces painful contractions of the muscles, whereas the smooth sinusoidal currents may cause equally powerful contractions, but they are not so much felt. They are also free from the electrolytic effects of a continuous current.

We distinguish yet between single-phase and polyphase sinusoidal currents. For medical purposes three-phase currents are frequently employed, and to obtain them a peculiar connection of the winding of the armature is necessary. It is arranged in three groups ; each of these groups occupies one-third of the circumference of the armature. One end of each group is connected with one of the three collecting rings, and the other ends of the three groups are connected together. Three separate waves are thus generated, and are interwoven, as shown in the illustration.

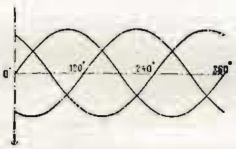


Fig. 22.

The most convenient way to produce sinusoidal currents is to have a continuous current motor provided with extra collector rings, from which the sinusoidal current can be taken off. If it has two rings, single-phase currents only can be obtained ; if it has three rings, single-phase or three-phase currents can be employed ; in the first case two, in the second case three, electrodes have to be used simultaneously on the patient.

The E.M.F. of the sinusoidal currents thus obtained depends on the E.M.F. of the current used for the motor, and in small transformers is approximately 60 per cent of it. For instance, if a 250-volt current is being used, the sinusoidal current obtained at the brushes will have about 150 volts. This would be too much for a patient, but it can be reduced by a simple transformer resembling a sledge coil. Such a transformer allows a very fine regulation of the current's strength, and a current transformed in this manner can be used with perfect safety in a bath, even if there should be a bad leakage to earth in the continuous current installation which is being used to run the sinusoidal transformer.

The number of periods depends on the number of revolutions of the armature, and can be varied by means of the rheostat from about 40 periods down to a few periods per second.

The current should not be switched off while it is at full strength, otherwise the patient might receive a shock similar to that obtained from a faradic coil. The sledge transformer has to be put on weak, and the full resistance should be inserted in the circuit of the motor before the electrodes are removed, or before the switch on the motor is turned off.

The alternating current from the main can be used for the application of single-phase sinusoidal currents, and the strength can be varied by means of a volt selector similar to those used for controlling the continuous current. If a leakage exists it would not be safe to apply the current in this manner in a bath, but it can be rendered absolutely safe by transformation, either by means of a suitably arranged sledge transformer, or by the combination of a transformer like No. 1928 with a volt selector.

X Ray Apparatus and their Management will be found in the second part of this book.

BOOKS ON ELECTRO-THERAPEUTICS.

The books marked (*) can be supplied by us.

*Albers-Schoenberg, Dr. Die Roentgen Technik. 1910. 3rd edition.

*Althaus, Julius, M.D., M.R.C.P., M.R.I. The Value of Electrical Treatment. 3rd edition. 1899. 3s. 6d.

*Bordier, H., Dr. Précis d'Electrothérapie. Preface de Mons. le Professeur d'Arsonval. 2nd edition. 1903. 8s.

*Bouchard, C. Professeur à la Faculté de Médécine. Traité de Radiologie Médicale. Paris. 1904. 1,100 pages. £1 6s.

*Bruce, W. Ironside, M.D. A System of Radiography, with an Atlas of the Normal. 1907. 15s.

Cleaves, M. A., M.D. Light Energy: its Physics, Physiological Action and Therapeutic Application. 1905. 811 pages. £1 1s.

*Dowse, T. S., M.D. Massage and Electricity in the Treatment of Disease. 4th edition. 1907. 7s. 6d.

*Fenwick, E. H., F.R.C.S. The Electric Illumination of the Bladder and Urethra.

*Freund, L., M.D. Elements of General Radiotherapy for Practitioners. Translated by G. H. Lancashire, M.D. With an Appendix by C. A. Wright, F.R.C.S. 1904. 600 pages. £1 1s.

*Gauss, Dr. Tiefentherapie in der Gynecology. 1912.

*Guilleminot, H. Electricité Médécale. 1905. 620 pages. 10s.

*Harris, W., M.D. Electrical Treatment. 1908. 7s. 6d.

*Hedley, W. S., M.D. Therapeutic Electricity. 1900. 8s. 6d.

*Jacoby, Dr. S. Lehrbuch der Kystoscopie und stereo-photographscher Atlas. 1911. 25s.

*Jones, Lewis, M.D. Medical Electricity. A Practical Handbook for Students and Practitioners. 6th edition. 1912. 12s. 6d.

*Leduc, Stephane, Prof. Electric Ions, and their Use in Medicine. 2s. 6d.

*Luke, Thomas D., M.D., F.R.C.S.Ed. A Manual of Natural Therapy. 1908.

*Morton, Reginald, M.D. Essentials of Medical Electricity. 2nd edition. 1909. 7s. 6d.

Morton, W. J., M.D. Cataphoresis, or Electric Medicamental Diffusion. 1898.

*Pilcher, Dr. S. M. Practical Cystoscopy. 1911. 24s.

*Potts, C. F., M.D. Electricity, its Medical and Surgical Applications, including Radiotherapy and Phototherapy. 1912. 18s.

*Pusey-Caldwell. The Roentgen Rays in Therapeutics and Diagnosis. 2nd edition. 1904. 600 pages. £1 1s

*Rockwell, A. D., M.D. Medical and Surgical Uses of Electricity. 1904. £1 10s.

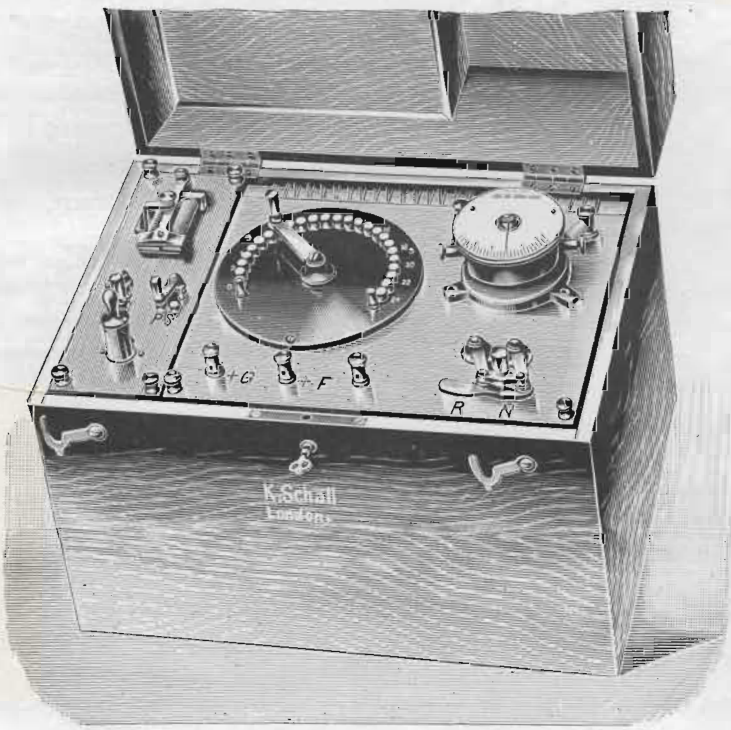
*Walsh, D., M.D. Roentgen Rays in Medical Work. 4th edition, 1907. 15s.

*Walsham, H., and Orton, C. The Roentgen Rays in the Diagnosis of Diseases of the Chest. 1906. 6s.

Illustrated Price List

OF

ELECTRO-MEDICAL APPARATUS.



SCHALL & SON,

71 and 75, NEW CAVENDISH STREET,

LONDON, W.

FIFTEENTH EDITION. JULY, 1913.

OUR INSTRUMENTS HAVE BEEN ORDERED BY

THE ADMIRALTY, THE WAR OFFICE. H.M. OFFICE OF WORKS, THE CROWN AGENTS FOR THE COLONIES, THE GOVERNMENTS OF INDIA, NATAL, EGYPT, TRANSVAAL, AND MANY OTHER COLONIES.

Charing Cross Hospital
Guy's Hospital
King's College Hospital
London Hospital
Middlesex Hospital
New Hospital for Women
Queen Alexandra Hospital
Royal Free Hospital
St. Bartholomew's Hospital
St. George's Hospital
St. Mary's Hospital
St. Thomas's Hospital
University College Hospital
University College
Westminster Hospital
St. Peter's Hospital
National Hospital for the Paralysed
Hospital for Epilepsy and Paralysis
Central London Ophthalmic Hospital
Royal Westminster Ophthalmic Hospital
Seamen's Hospital

And over 25 smaller Hospitals in London

Royal Infirmary, Aberdeen
" " Belfast
" " Bristol
" " Derby
" " Dover
" " Dumfries
" " Dundee
" " Edinburgh
" " Glasgow
" " Gloucester
" " Halifax
" " Hull
" " Lancaster
" " Liverpool
" " Manchester
" " Newcastle-on-Tyne
" " Preston
" " Salford
" " Sheffield
" " Southampton
" " Stirling
" " Windsor
General Hospital, Birmingham
" " Bristol
" " Burton-on-Trent

And over 300 other Hospitals in Great Britain

FARADISATION.

(*See also pages* 28-34.)

No. 5

No. 6.

No. 5. Dr. Spamer's Coil, in polished mahogany case, cheap form, with dry cell, cords, handles, and 4 electrodes (Fig. 5) £1 2 6

Size 5 by 5 by 5½ in., weight 2¾ lbs.

No. 6. Dr. Spamer's Coil, in polished mahogany case, with dry cell, commutator for primary and secondary current, cords, handles, and 5 electrodes (Fig. 6) .. 1 18 0

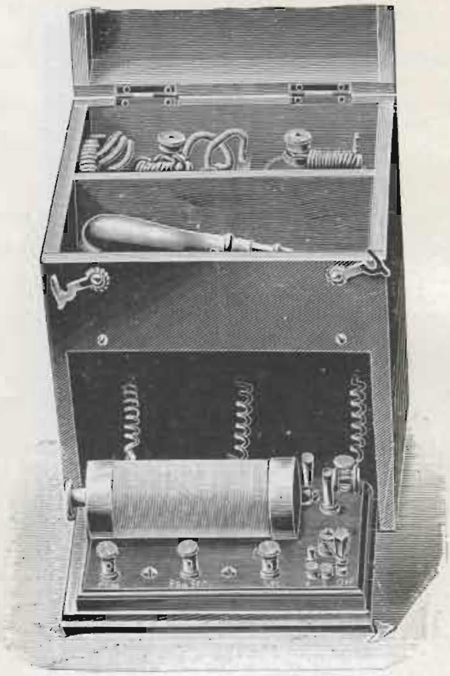
Size 5 by 5 by 5½ in., weight 3 lbs.

This coil is bought more frequently than any other type : there are several thousands of them in use already.

No. 7. Similar Coil, with two dry cells instead of one .. 2 6 0

If desired, we can supply the coils Nos. 5 to 7 with bichromate cells instead of the dry cells, but we recommend the acid cells only if the coil is to be used in some part of the world where it is difficult to get the dry cell replaced. The dry cells have great advantages compared with the acid cells : they are more convenient, portable, and clean. It is only the spilling of acid which necessitated the frequent repairs to coils in former years, and since we began to use dry cells in the year 1891, the repairs have ceased.

The size and quality of the cells chosen is such that one cell will work a coil for about 40 hours before it becomes exhausted. With an average use of ten minutes a day, the cell has to be renewed about once in a year. Price of new cell, including postage, 2s. 6d.



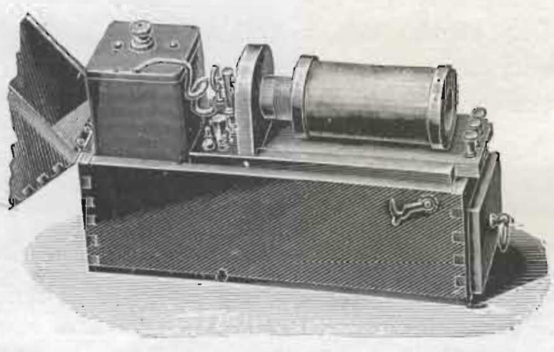
No. 8.

No. 8. Coil, with two *large* dry cells, working the coil for over 100 hours; in polished walnut case, size $6 \times 6 \times 7\frac{1}{2}$ inches, weight 5 lbs (Fig. 8) .. **£2 0 0**

Dr. Morton Smart and Mr. Rowley Bristow have succeeded in constructing a coil which produces *painless* muscular contractions, and the amount of this contraction can be exactly controlled and may be tuned rhythmically by placing a metronome interrupter in circuit if desired.

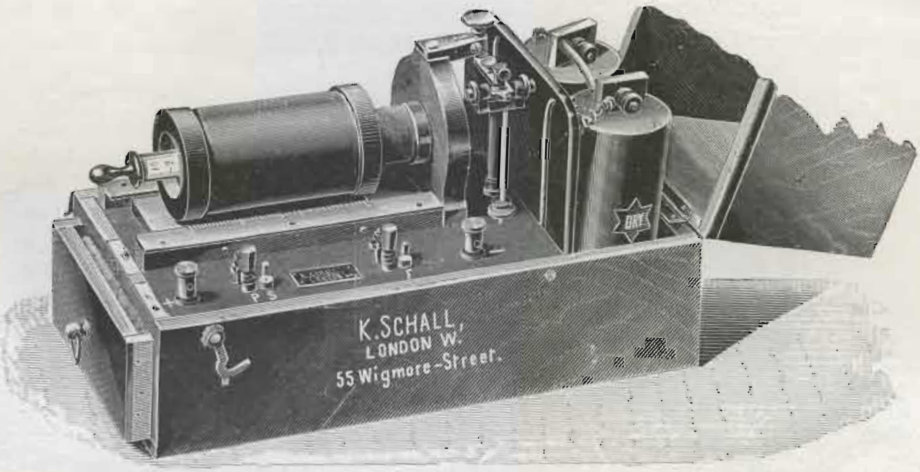
Price of the apparatus .. **£5 10 0**

(An illustration of it will be ready shortly, see also *Lancet*, May 4th, 1912).



No. 19.

No. 19. Dr. Lewis Jones' Sledge Coil, with one large dry cell, working the coil for about 80 hours altogether, cords, handles, and 5 electrodes, in walnut case (Fig. 19) **£2 0 0**

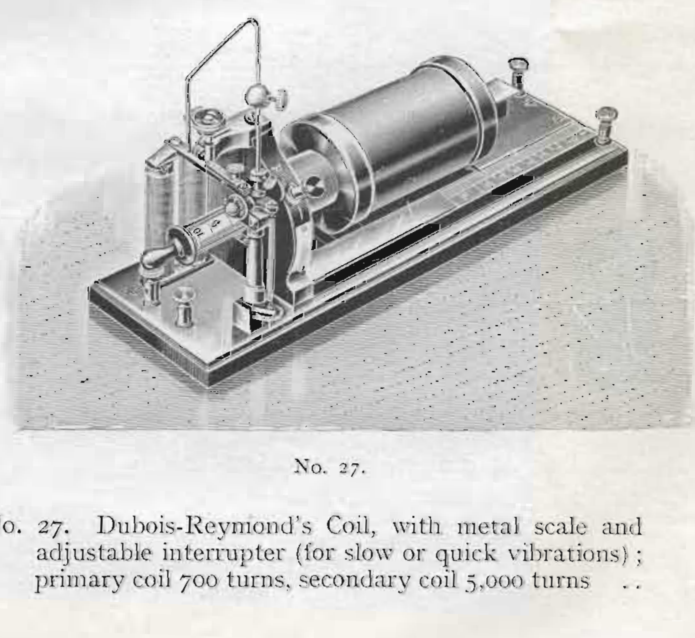


No. 21.

No. 21. Dubois-Reymond's Coil, with two dry cells, in polished mahogany case, commutator for primary and secondary current, cords, handles, and six electrodes, size 5 × 11 × 7 inches, weight 6 lbs. (Fig 21) .. **£4 10 0**

This is the most complete and convenient of all the portable coils for diagnosis as well as for treatment. The rapidity of the interruptions may be regulated by means of a weight, which can be fixed higher or lower. The cells will work the coil for more than 80 hours altogether.

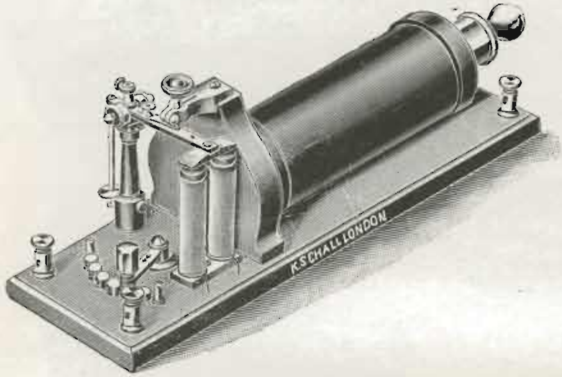
Spare Cells for the Coils No. 19 and No. 21, 2s. 6d. each.



No. 27.

No. 27. Dubois-Reymond's Coil, with metal scale and adjustable interrupter (for slow or quick vibrations); primary coil 700 turns, secondary coil 5,000 turns .. **£2 15 0**

No. 35.	Dr. de Watteville's Coil, for primary current only ..	£3 0 0
No. 36.	Same Coil, complete with 2 dry cells, cords, and 2 large bath electrodes	4 0 0



No. 35.

This coil is especially suitable for the electric bath, and for treatment of the abdomen with faradisation. The strength of current is regulated partly by drawing out an iron core, and partly through a crank, by means of which 2, 4, 6, 8, or 10 layers of the copper wire may be thrown in or out of circuit. The number and rapidity of interruptions may be regulated by altering the position of the ball.

For Leduc's apparatus for administering interrupted currents, and for Lewis Jones' Rhythmical interrupter, see No. 245 and 248, pages 66–68.

We have supplied coils No. 21, amongst others, to :—

King's College; St. Thomas's; Westminster Hospital; Royal Hospital for Women and Children, Waterloo Bridge Road; Victoria Hospital, Chelsea; Westminster Medical School; Seamen's Hospital, Greenwich; London County Asylum, Claybury; Metropolitan Hospital, Kingsland Road, London; Royal Infirmary, Halifax and Derby; Cottage Hospital, Aberdare; Grimsby District Hospital; Eye Infirmary, Newcastle; Royal Berkshire Hospital, Reading; Children's Hospital, Gloucester; Dispensary, Nottingham; South Charitable Infirmary, Cork; General Infirmary, Hertford, etc., etc., and to several hundred medical men.

LECLANCHÉ DRY CELLS.

No. 80.

No. 82.

No. 90.

No. 80.	Hellesen Cell, $4\frac{1}{2}$ inches high $\times 1\frac{1}{2} \times 1\frac{1}{2}$ inches	..	£0 1 6
No. 82.	Obach Cell, R, 5 inches $\times 1\frac{3}{4} \times 1\frac{3}{4}$ inches	..	0 2 3
No. 83.	,, ,, Q $5\frac{1}{2}$,, $\times 2 \times 2$,,	..	0 2 6
No. 84.	,, ,, S $6\frac{1}{8}$,, $\times 2\frac{1}{4} \times 2\frac{1}{4}$,,	..	0 2 9
No. 90.	,, ,, C $6\frac{1}{4}$,, $\times 2\frac{3}{16}$ diam.	..	0 2 6

BATTERIES FOR GALVANISATION AND ELECTROLYSIS.

(See also pages 7-16.)

PORTABLE LECLANCHÉ BATTERIES.

If not otherwise ordered, the batteries Nos. 99–132 will be charged with dry cells; they can be sent as ordinary freight all over the world. If desired, the batteries can be charged with liquid cells.

The re-charging of the batteries costs 8d. per cell if they are filled with liquid cells, and 1s. 6d. per cell if they are filled with dry cells.

Provided the batteries are not short circuited, batteries Nos. 99—132 are guaranteed to last with average use for two years before requiring re-charging. For combined batteries, the two cells working the coil may require re-charging earlier.

No. 103.

Schall's Batteries for Patients and Nurses, in oak cases, with cords, handles, and three electrodes.

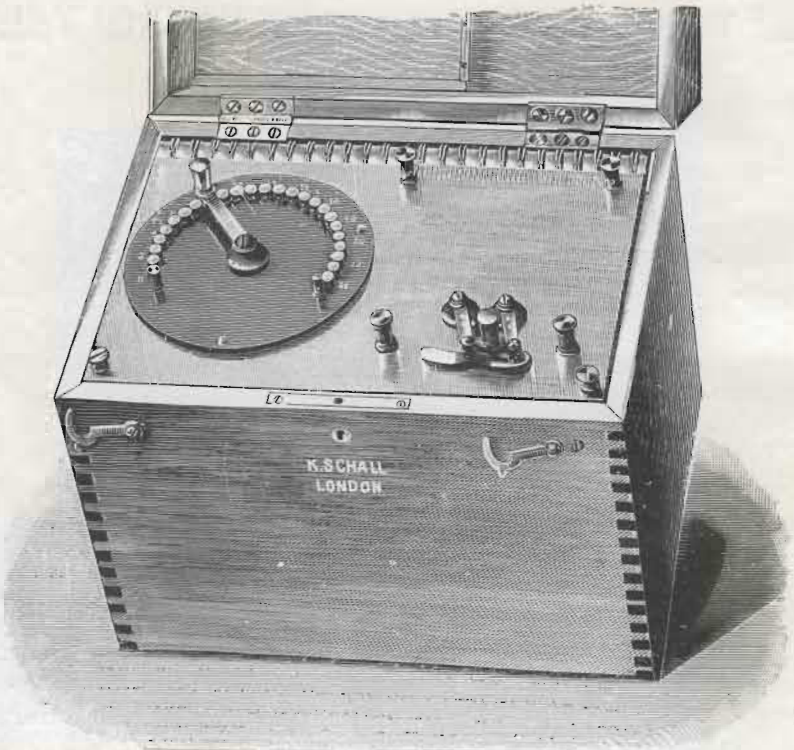
The strength of the current can be regulated without giving shocks to the patient, by increasing or diminishing the number of cells (two at a time) by means of the forked cord *a b*.

*No. 99.	6 cells	..	.. ..	£1 1 0
†No. 100.	8 ,,	$3\frac{1}{2}\times5\times6\frac{1}{2}$ inches, weight	6 lbs.	1 12 0
†No. 101.	12 ,,	$5\times5\times6\frac{1}{2}$,, ,,	$9\frac{1}{2}$ lbs.	2 0 0
No. 102.	18 ,,	$5\times9\frac{1}{2}\times6\frac{1}{2}$,, ,,	$12\frac{1}{2}$ lbs.	2 12 0
No. 103.	24 ,,	$7\frac{1}{2}\times10\times6\frac{1}{2}$,, ,,	18 lbs. (Fig. 103)	3 3 0
No. 104.	32 ,,	$8\times14\times6\frac{1}{2}$,, ,,	24 lbs.	4 2 0
No. 105.	40 ,,	$8\times17\times6\frac{1}{2}$,, ,,	30 lbs.	5 0 0

* Suggested by Mr. Cardew, for treating exophthalmic goitre (Graves' disease).

† For throat, ear, and eye diseases; for removing hairs by means of electrolysis, etc.

Schall's Batteries, with current collector, reverser, cords, handles, and four electrodes (oak case).



No. 117

No. 116, 18 cells, $4\frac{1}{2} \times 9\frac{1}{2} \times 11$ inches, weight	16 lbs.	..	£4 6 0
No. 117, 24 ,, $7 \times 11 \times 11$,, ..	21 lbs. (Fig. 117)		5 2 0
No. 118, 32 .. $7 \times 13\frac{1}{2} \times 11$ . .	29 lbs.	.	6 6 0
No. 119, 40 ,, $7 \times 17 \times 11$,, ,,	37 lbs.	.	7 10 0

Of the many unsolicited testimonials we have received about batteries Nos. 99-140, we will mention one only.

The late Dr. Milne Murray, of Edinburgh, wrote :—

"The Combined Battery (No. 132) I bought some three or four years ago will soon want re-charging. It has done me splendid service, and I am greatly pleased with it. I have never had any trouble with it, and though I have used it now steadily all these years, and made thousands of applications with it, it is still giving a good current.

No. 117A.

Schall's Combined Batteries.—With current collector, reverser, coil No. 6, and large dry cell, cords, handles, and 5 electrodes. The galvanometer shown in illustration is 30s. extra.

No. 116*a*, 18 cells	..	£6	5	0
No. 117*a*, 24 ,, (Fig. 117*a*)	..	7	0	0
No. 118*a*, 32 ,,	..	8	4	0

Schall's Batteries, with double collector, current reverser, galvanometer (No. 271), cords, handles, and five electrodes.

No. 122, 24 cells, 7 ×11 ×11 inches, weight 22 lbs.	..	£10	0	0
No. 123, 32 ,, 7 ×13½×11 ,, ,, 30 lbs.	..	11	0	0
No. 124, 40 ,, 7 ×16 ×11 ,, ,, 38 lbs.	..	12	0	0

Batteries Nos. 122–124 are similar to Fig. 132; the only difference is that the latter is provided with a faradic coil, shown on the left hand side, which is not supplied with batteries Nos. 122–124.

For apparatus for utilizing the current supplied from dynamos for galvanisation, electrolysis and faradisation, see Nos. 1820–1840.

No. 132.

Schall's Combined Batteries, with double collector, current reverser, galvanometer No. 271, coil No. 27, Dr. de Watteville's commutator, cords, handles, and seven electrodes.

No. 130.	24 cells,	$7 \times 13 \times 11$ inches,	weight	34 lbs.	**£12 15 0**
No. 131.	32 „	$7 \times 15\frac{1}{2} \times 11$ „	..	42 lbs.	**14 10 0**
No. 132.	40 „	$9 \times 16\frac{1}{2} \times 11$ „	„	48 lbs. (Fig. 132)	**16 5 0**

There are over a thousand of our Leclanché batteries, Nos. 116–132, already in use. They have been supplied, amongst others, to :—

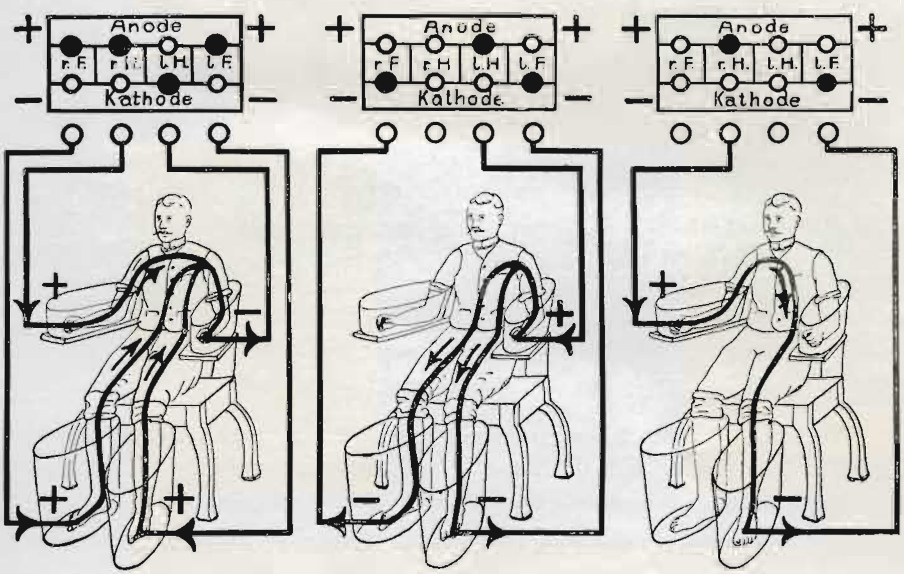
The Admiralty, the War Office, H.M. Office of Works, the Crown Agents for the Colonies, Guy's Hospital, King's College Hospital, St. Mary's Hospital, St. Thomas's Hospital, London Hospital, Queen Alexandra Maternity Hospital, University College Hospital, Westminster Hospital, National Hospital for Diseases of the Heart, Victoria Hospital, Central Ear and Throat Hospital, General Dispensary, Marylebone ; London County Lunatic Asylum, Hanwell ; Royal Victoria Hospital, Bournemouth ; Royal United Hospital, Bath ; Army Medical Service, Netley ; Dispensary, Exeter ; Devon and Exeter Hospital, Exeter ; Whitworth Hospital, Mater Misericordia Hospital, Royal Infirmary, Dublin ; Hospital for Sick Children, Aberdeen ; Manchester Southern Hospital ; Infirmaries in Macclesfield, Southport, West Riding, Carlisle, Workington, Dundee, Downpatrick, Greenock, Waterford, and Worcester ; County Asylums, Whittingham, York, and Dorset ; Haywood Hospital, Burslem ; Addenbrooke Hospital, Cambridge ; Grimsby District Hospital ; Manchester Children's Hospital, Birkenhead Children's Hospital ; Cottage Hospital, Shaftesbury and East Cowes ; Royal Infirmary, Derby, and to over a thousand physicians and surgeons.

DR. SCHNEE'S FOUR-CELL BATH.

In this bath only the arms and feet of the patient are immersed in water.

This is the most convenient method of administering electric currents to patients which we possess. Compared with an electric bath, the advantages are that the patient need not undress completely, that the strength of the current passing through the body can be measured accurately, and that the doctor is not dependent on a bathroom in order to use this method.

We do not need to press the electrodes all the time to the skin, nor are there any fluctuations in the strength of the current owing to uneven pressure, which frequently causes pain. The surface through which the current enters is large, and comparatively strong currents can be used without discomfort to the patient. The resistance of the skin is reduced by the action of the water.



The method is also very convenient for ionic medication, i.e., for the introduction of chemicals through the skin. The advantage of this is that the chemicals remain suspended for a longer time in the cells of the tissues of those parts where their action is desired. If injected hypodermically or introduced through the stomach, they are less active because they are washed away rapidly by the circulation of the blood.

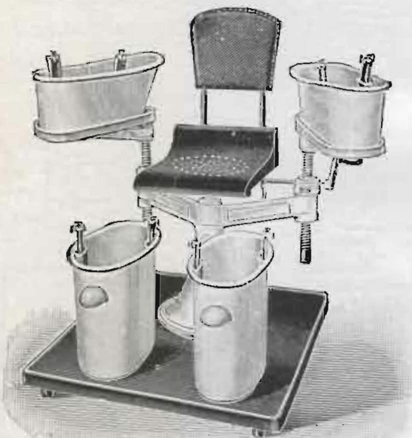
The direction of the current can be varied by means of a commutator; many different combinations are thus possible; three of them are shown in the diagram.

The four-cell bath can be used with the galvanic, faradic, or sinusoidal currents produced by batteries or by dynamos; in the latter case there is no danger of shock, because these porcelain tubs are not connected with the water pipes, and are well insulated from earth. The quantity of

water required is not great; the apparatus does not therefore depend on the proximity of a water supply.

No. 180. Complete outfit of Dr. Schnee's Four-cell Bath, consisting of a pantostat No. 2005 for galvanisation, faradisation and sinusoidal currents, with galvanometer, reverser, etc.; commutator to control the direction of the current; and four porcelain tubs with carbon electrodes. The tubs for the arms can be raised or lowered £33 10 0

For illustration of the pantostat, *see* Fig. 2005.



No. 181.

No. 182.

To enable those of our customers who have already a suitable battery or switchboard to use with the four-cell bath, we can supply the following parts separately :—

No. 181. Chair, commutator to control the direction of the current, and four porcelain tubs with carbon electrodes (Fig. 181) £22 0 0

The chair shown in Fig. 181 is made of iron in a very substantial manner, with arrangement to raise the seat and adjust the height and the distance of the two supports for the arm-bath by means of a screw gear. This is very convenient, but somewhat expensive. The four-cell bath can also be used by placing the patient on an ordinary chair, and the two arm-baths on separate stands of convenient height, as shown in Fig. 182.

No. 182. Two porcelain tubs for the feet, two for the arms, and stands for the latter (as shown in Fig. 182), four carbon electrodes, and crank commutator to control the direction of the current £14 0 0

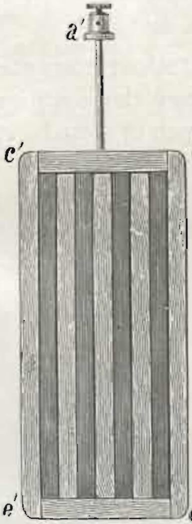
The chair shown in Fig. 182 is not included in this price.

No. 183. Separate tub for foot, Doulton ware, with carbon, electrode, and terminals £0 18 0
No. 183a. Similar tub, of white porcelain 1 10 0
No. 184. Ditto for arm, Doulton ware ditto 0 16 0
No. 184a. Ditto of white porcelain ditto 1 6 0
No. 185. Commutator to control the direction of the current, with the necessary terminals, etc., mounted on ebonite 1 15 0

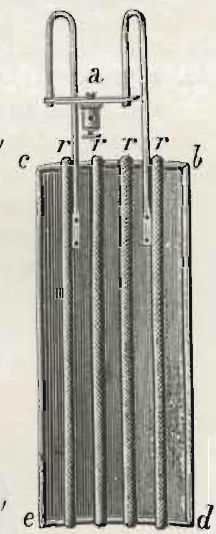
ELECTRIC BATH.

Any wooden or porcelain bath tub is suitable for an electric bath. Metal tubs may be insulated to a certain extent by means of bath enamels, so that the electric current can therein be applied to the patient. Tin electrodes, about 10 inches square, are immersed in the water at the upper and lower ends, or else the electrodes shown in Nos. 195—198 can be used.

No. 195. Large Bath Electrode, Fig. 195 .. £0 16 0
No. 196. The same, bent for the head or foot end of the tub, Fig. 196 .. 0 18 0



No. 195.



No. 196.


No. 198.

No. 198. Paddle Electrode, Fig. 198 .. .. .. £0 14 0

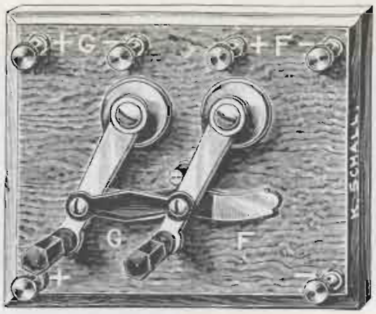
For Tin Electrodes, see Nos. 480—497.

In this way any bath tub can be made fit for the treatment of a patient with the electric current. The Induction Coil No. 35 is specially recommended if the faradic current is used. The Batteries Nos. 116—132 are suitable for applying the galvanic, faradic, or combined currents.

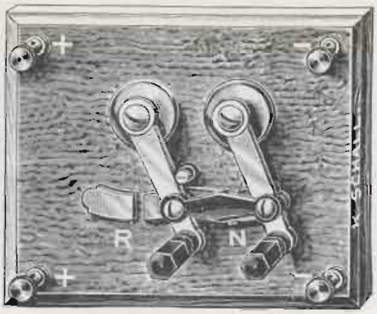
CURRENT REVERSERS, COMMUTATORS, &c.

(*See also pages* 12 and 13.)

No. 222. **Current Reverser and Interrupter,** Fig. 222 .. .. £0 12 0
No. 232. Dr. de Watteville's Commutator, for the use of galvanic, faradic, or combined currents, Fig. 232 .. .. 0 14 0
No. 240. Metronome Interrupter, with two mercury cups. The number of interruptions can be varied from 20 up to 300 per minute 3 0 0



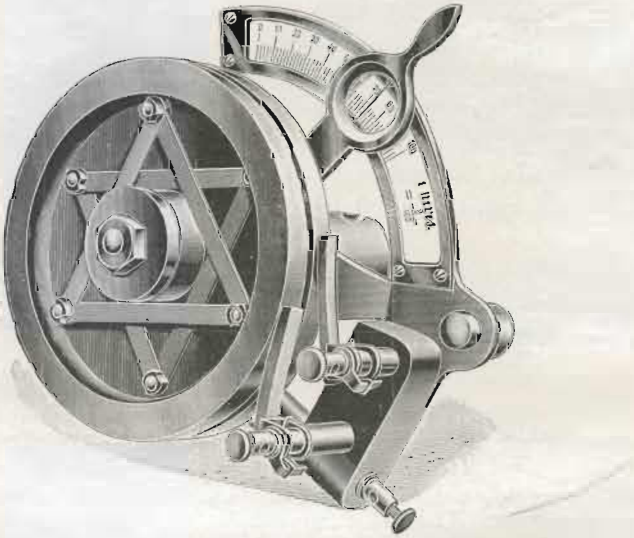
No. 232.



No. 222.

No. 245. Prof. Leduc's Interrupter, with adjustable brushes and scale to vary the duration of the time during which the current is open or closed £3 5 0

No. 246. Prof. Leduc's Interrupter and Reverser. The current can be reversed up to 200 times per second. This apparatus can also be used to produce the electric anæsthesia described by Prof. Leduc (Fig. 246) 6 0 0



No. 246.

These interrupters or reversers can be attached to any of our motors or pantostats.

Prof. Leduc has published most interesting results, which he obtained with pulsating unidirectional currents produced by means of an adjustable interrupter as shown above, which has to be attached to an electric motor, and connected with a continuous current battery of 10 to 20 volts and a milliampèremeter.

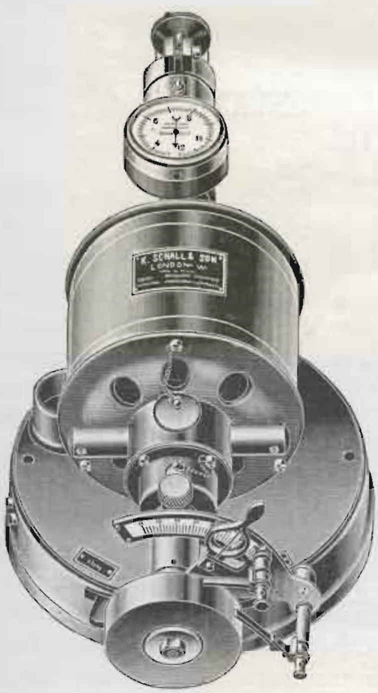
He found that the human body reacts most powerfully if there are 100 interruptions per second. If this frequency is increased or reduced, the susceptibility diminishes. It is possible by means of this interrupter to produce gradually, *with remarkably weak currents*, single contractions, tetanus, local anæsthesia, general anæsthesia, paralysis of the respiration, of the heart, and ultimately death. The

electric sleep can be prolonged for hours, and full consciousness returns immediately after the cessation of the current without any ill effects, or feeling unwell. The method has been used already in laboratory experiments upon animals; the anæsthesia has been prolonged for eight hours, without a single accident or noticeable ill effect, and it can also be used for local anæsthesia for minor operations.

Moreover, the apparatus can be used for faradisation, for diagnosis as well as for treatment. It is superior to faradic coils, because dosage is impossible with the latter, whereas Leduc's currents can be measured accurately with a M.A. meter. The time during which the current is closed can be varied by altering the position of the handle above the scale, from $\frac{1}{10}$th up to $\frac{9}{10}$th part of the duration of each interruption. The scale shows approximately the time the current is "on" compared with the time it is "off"; with a M.A. meter this proportion can be ascertained quite accurately. Full particulars about this will be given in the directions for use sent with our apparatus.

A very interesting article about the effects which can be produced with Leduc's currents appeared in the *Archives of the Röntgen Rays*, May, 1912, pp. 464–469.

No. 247. Speedometer, to indicate the number of revolutions of Leduc's Interrupter, per minute, shown in illustration .. **£3 15 0**



No. 247.

No. 248.

Leduc's Interrupter is incomplete without an arrangement to indicate the number of interruptions per second, so that the speed of the motor can be adjusted to give the correct frequency. The illustration shows the Leduc Interrupter, No. 245, and the Speedometer, No. 247, attached to a Motor, No. 1411.

No. 248. Dr. Lewis Jones' Rhythmic Interrupter (Fig. 248) .. **£4 0 0**

By means of this interrupter, galvanic, faradic, or sinusoidal currents

can be made to increase and decrease in slow rhythms, about once in every four seconds. The tissues become stimulated, but as time is given for the renewal of the blood supply, no fatigue is produced as is the case in sustained tetanus of the muscles. After the muscles of the hind limb of a rabbit were stimulated for 10 minutes daily for 20 days, it showed an increase of 40 per cent over the weight of the corresponding untreated limb. (See "Rhythmic Interrupters," by Dr. Lewis Jones, *Lancet*, Nov. 13th, 1909.)

The interrupter has to be attached to a motor; the Pantostat No. 2005 is the most convenient, because in addition to the motive power required for the interrupter, it supplies also the necessary galvanic or sinusoidal current. But if a pantostat is not available, any other of our motors can be used, and the interrupter has then to be inserted in the circuit of a galvanic or a faradic battery. Full instructions are sent with the apparatus.

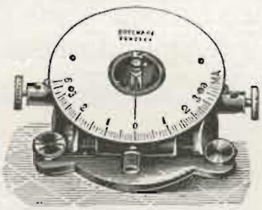
MILLIAMPÈREMETERS, RHEOSTATS, &c.

(*See also pages* 10–12.)

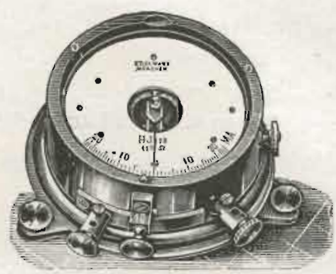
There are two types of milliampèremeters. The older one has a horseshoe magnet, which is provided with an index pointing north. These instruments can only be used in a horizontal position, and their reading becomes inaccurate while used in the neighbourhood of magnets or the current from the main. Experience has shown, however, that these instruments require practically no repairs; the needle on which the magnet oscillates becomes blunt in course of time, but it can easily be replaced by a new sewing needle by the owner, without having to return the instrument to the manufacturer. In consequence of this reliability we still continue to make these galvanometers, and recommend them especially for portable batteries.

The newer type is provided with a movable solenoid; these instruments can be used in a horizontal or vertical or any other position, and their readings are not affected even when used near dynamos. They are therefore more convenient than the older type, and have superseded them to a large extent; they have to be used for all switchboards for the current from the main. They are, however, more delicate than the old instruments. The current has to pass through two fine hair springs, and if it is too strong the elasticity of these springs changes, and the index does not point to 0 any more. Such an overdose may be caused if the connecting cords or electrodes touch one another accidentally. They then have to be returned for repairs.

No. 264. Galvanometer, in cardboard box, showing up to 6 milliampères each 10-th part of a milliampère, Fig. 264 ..	£1 10 0
No. 265. The same instrument, showing up to 30 milliampères each single milliampère	1 10 0



No. 264.



No. 271.

No. 270. Galvanometer, in polished mahogany box, showing up to 5 milliampères every 10-th part of a milliampère; or by using the shunt, each single milliampère up to 50 milliampères £2 14 0

No. 271. The same instrument, showing each single milliampère up to 25; or by using the shunt, every 10 milliampères to 250 m.a., Fig. 271 .. .. 2 14 0

No. 288.

No. 280. Small d'Arsonval Galvanometer, diameter 2½ inches, reading up to 10 or 25 milliampères without shunt £2 0 0

No. 281. Similar instrument, reading up to 25 milliampères, or with shunt up to 100 or 250 milliampères .. 2 4 0

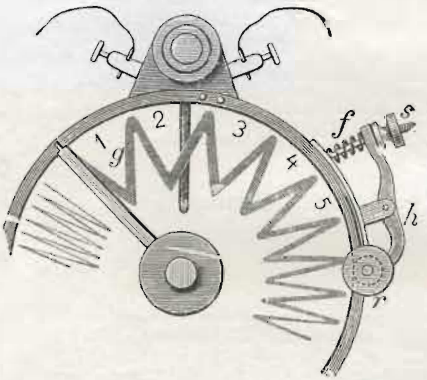
No. 284. D'Arsonval Galvanometer, diameter 4½ inches, reading up to 10 or 25 milliampères, without shunt .. 2 18 0

No. 285. Similar instrument, diameter 4½ inches, reading up to 5 milliampères, or with shunt up to 50 milliampères 3 5 0

No. 286.	Similar instrument, reading up to 25 or 250 milliampères	£3 5 0
No. 288.	Similar instrument, Fig. 288, with 2 shunts, reading up to 5, 50 and 500 milliampères	3 10 0

For **Amperemeters** and **Voltmeters**, see Nos. 950—980, pages 85 and 86.

GRAPHITE RHEOSTATS.



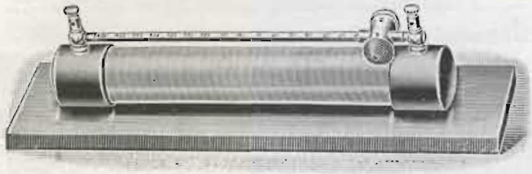
No. 306.

No. 306. Rheostat with mercury contact, total resistance about 20,000 ohms, which can be diminished *gradually*, without any jumps, down to about 20 ohms, by turning the glass dial, Fig. 306, £1 17 0

Nos. 308—319.

Rheostats with sliding spring; the resistances can be varied *gradually*, without any jumps.

No. 308.	From	3 to	200 ohms	. .	£0 18 0
No. 309.	,,	5 to	600 ..		0 18 0
No. 310.	,,	5 to	1,000 ..	.	0 18 0
No. 311.	..	10 to	5,000 ..	.	0 18 0
No. 312.	..	25 to	10,000 ..		0 18 0
No. 313.	..	50 to	25,000 ..	. .	0 18 0
No. 314.	,,	50 to	50,000 ..		1 0 0
No. 316.	,,	100 to	100,000 ,,	. . .	1 0 0



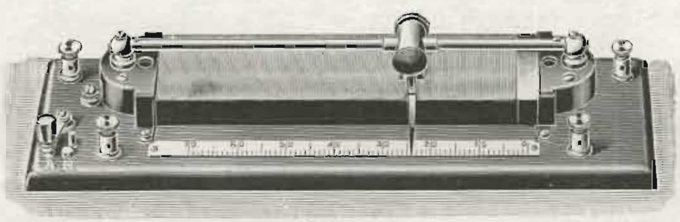
No. 323

No. 323.	**Metal Rheostat,** with about 1,000 contacts, Fig. 323—	
	(*a*) Total resistance, 2,500 ohms ..	£1 4 0
	(*b*) ,, ,, 5,000 ,, ..	1 4 0
No. 324.	Similar Rheostat, with about 100 contacts—	
	(*a*) Total resistance, about 5,000 ohms .	1 10 0
	(*b*) ,, ,, .. 10,000 ,,	1 14 0
	(*c*) ,, .. . 20,000 ,,	1 17 0
	(*d*) ,, ,, ,, 50,000 ,,	2 2 0
	(*e*) ,, ,, ,, 100,000 ,, ..	2 10 0

These Rheostats are only suitable for currents not exceeding 0·2 ampère.

SHUNT RHEOSTAT (VOLT REGULATOR).

(*See also pages* 36–37.)



No. 327.

No. 327.	Volt Regulator, Fig. 327, mounted on board with terminals	£1 16 0
No. 328.	Double Volt Regulator	3 0 0

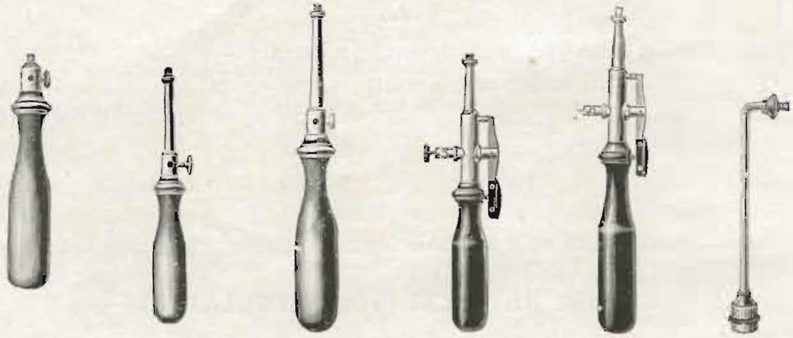
These rheostats consist of a slate core 9½ inches long, round which are wound about 500 turns of a fine insulated wire. The E.M.F. at the terminals can be increased or reduced by small fractions of a volt by moving the sliding contact; for instance, if the E.M.F. of the current passing through the rheostat is 50 volts, the current which is obtained at the terminals of the volt regulator rises or falls 0·1 volt only for every new turn of wire with which the sliding spring is brought in contact. For some laboratory experiments it may be desirable to obtain a still finer graduation, and in such a case a second volt regulator may be added.

These volt regulators are chiefly employed to utilize the current from the main for galvanisation, electrolysis, sinusoidal faradisation, etc. They are also very convenient if a battery of accumulators has to be used for these purposes.

CONNECTING CORDS.

No. 329.	12 yards insulated copper wire .	1/0
No. 330.	One pair of cords, for galvanisation, faradisation, or electrolysis, covered with silk, 1½ yards long	2/3
No. 332.	Ditto ditto 2 yards long ..	3/–
No. 336.	Separate terminals to be attached to silk cords .. each	–/6

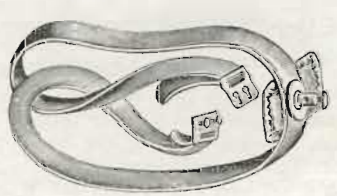
ELECTRODES.



370. 371. 372. 376. 377. 385.

No. 370.	Simple Handle, 3 inches long	1/6
No. 371.	,, 4 ,, ...	2/6
No. 372.	,, 5 ,, ...	3/-
No. 376.	Handle for *interrupting* the current, 5 inches long . .	7/-
No. 377.	,, ,, ,, 6 ,, ...	7/6
No. 381	Handle for *making* the current, 5 inches long . . .	7/-
No. 382.	,, ,, ,, 6 ,, ...	7/6
No. 385.	Connecting piece for fixing the electrodes at a right angle to the handles, Fig. 385	2/-

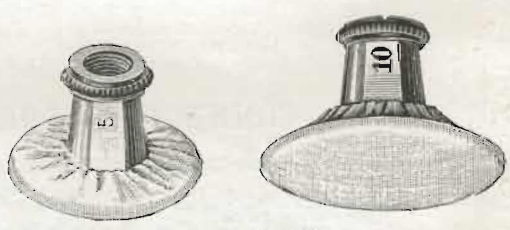
No. 412.



No. 418.

No. 412.	Bracelet for fixing electrodes to the arms or wrists	4/6
No. 418.	Belt Electrode, by Beard and Rockwell. . . .	6/6

Nos. 430–432.



Nos. 442–449.

No. 430.	Button shape Electrodes, small	1/3
No. 432	,, ,, ,, large	1/6

Round Tin Plates, covered with cotton.

No. 442.	¾ inch diameter	**1/4**	No. 445.	2 inches diameter	**2/-**
No. 443.	1 ,, ,,	**1/6**	No. 447.	3 ,, ,,	**2/9**
No. 444.	1½ ,, ,,	**1/9**	No. 449.	4 ,, ,,	**4/-**

No. 395.

No. 395. Double Pole Electrode (Fig. 395), to combine electric treatment with massage **15/-**

No. 453.

Round electrodes, with an arrangement which makes it possible that for each patient a *new and clean cover* can be fastened over the electrode by means of a celluloid ring.

The illustration on the right shows the ring only, the illustration in the centre shows the electrode with a new cover ready to be slipped over it, and the illustration on the left shows the complete electrode, with cover held in position by the ring.

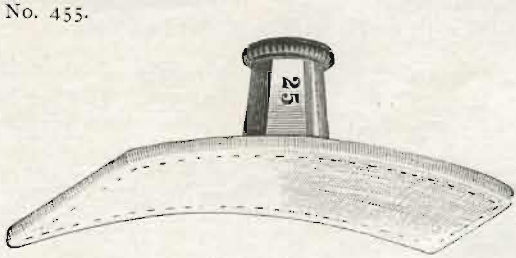
No. 453.	¾	1¼	1½	2	2½	3¼	4	5 ins. diam.
	1/9	**2/-**	**2/6**	**3/-**	**3/6**	**4/-**	**5/6**	**7/-**

No. 455.

No. 455. New Electrodes, with changeable cover and strong handle, Fig. 455 (recommended by Dr. Lewis Jones), diameter 2½ ins. . **6/6**

,, 4½ ins. **8/6**

,, 5½ ins. .. **9/6**



Nos. 460—470.

Square Flexible Electrodes, of tin, with leather covers.

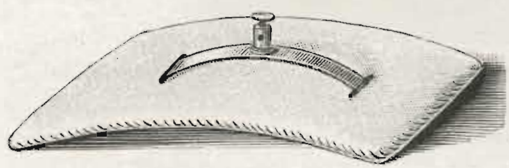
No. 462.	2 square inches	**1/9**	No. 468.	8 square inches	**3/9**
No. 464.	4 ,, ,,	**2/3**	No. 470.	12 ,, ,,	**4/6**

Nos. 442—449 and 460—470, with carbon plates and leather cover, 50 per cent. more.

Flexible tin Electrodes, with white flannel covers and terminals, back of the electrode covered with wax cloth (see illustration No. 103, page 59).

No. 480.	$2\frac{1}{2} \times 4$ inches ..	**1/3**	No. 493.	$4\frac{1}{2} \times 8\frac{1}{2}$ inches ..	**2/6**
No. 483.	$2\frac{3}{4} \times 5$,, ..	**1/6**	No. 495.	$5 \times 8\frac{1}{2}$,, ..	**3/-**
No. 489.	$3\frac{1}{2} \times 6$,, ..	**1/9**	No. 497.	6×10 ,, ..	**4/-**

No. 500.
Flexible Metal Gauze Electrodes, with sponge, according to sizes, **5/-** to **12/-**



No. 510.

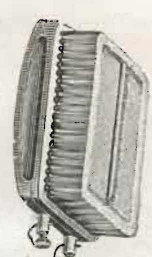
Nos. 525—528.

No. 510.	Large Indifferent Electrode, 3×6in. ..	..	**7/-**
No. 525.	Flexible Pillow Electrodes ..	70 square inches	**10/-**
No. 526.	,, ,, ,, ..	100 ,, ,,	**12/-**

No. 545.

Nos. 540—542.

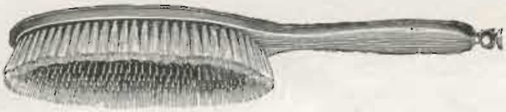
No. 550.



No. 555.

Brush electrodes with metal wire, without handles—

No. 540.	Small	**1/6**	No. 550.	7 sq. inches Fig. 550	**7/-**
No. 542.	Large	**2/6**	No. 555.	Double brush, 9 square inches, Fig. 555	**10/6**
No. 545.	$2\frac{1}{2}$ sq. ins. (Fig. 545)	**5/6**			



No. 557. Large brush, with handle, Fig. 557 .. **9/6**

No. 557.

 No. 559. Comb Electrode, Fig. 559 .. .. 3/-

No. 590.

No. 573.

No. 572.

No. 587.

No. 560.

No. 585.

No. 560. Electrode for larynx, with olive shaped button, shaft insulated with gutta-percha, Fig. 560 .. .. 2/6

No. 570. Electrode for rectum, 3 sizes .. .. .. each 4/6

No. 572. Zinc Electrode for rectum, Fig. 572 . .. 3/-

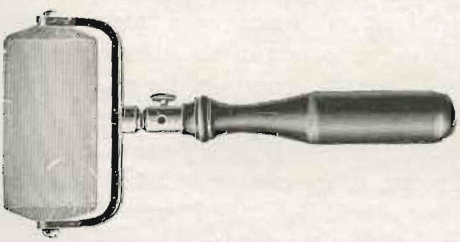
No. 573. Electrode for rectum, with douche, Fig. 573 . 8/-

No. 585. Electrode for the ear, Fig. 585 . . 8/-

No. 587. Double Electrode for the ear, Fig. 587 .. .. 12/-

The two electrodes are insulated from one another, and can be used bipolar or monopolar, as desired.

No. 590. Electrode for penis, Fig. 590 .. .. 8/-



No. 603.

No. 604.

No. 600. Wheel Electrode, $1\frac{1}{2}$ inch long, without handle . .. 4/9

No. 602. .. .. $2\frac{1}{2}$ inches long .. 5/9

No. 603. ,, ,, $3\frac{1}{2}$,, Fig. 603 .. 7/-

No. 604. Double Wheel Electrode, with handle, Fig. 604 . 12/6

IONIC MEDICATION.

(About Ions and Ionic Medication, see also pages 18–20.)

Any salt or alkaloid or acid solution can be introduced through the skin by means of an electric current. All the *metal* parts in the solution (zinc, lithium, magnesium, copper, etc.), the *alkaloids*, and hydrogen have a positive electric charge. They are repelled from the positive electrode and wander towards the negative one, the *cathode*, which attracts them, and these are therefore called the cations.

The acid radicals have a negative charge, and wander therefore from the negative towards the positive electrode, the *anode*, and are called the anions. Iodine, chlorine, etc., wander also from the negative towards the positive electrode.

The effects produced by the various drugs correspond to the chemical and physiological effects peculiar to the salts or alkaloids or acids used.

The *quantities* of chemicals which can be thus introduced are in proportion to the strength of current × the time for which it is applied. The degree of concentration of the solution has no effect on the quantity of chemicals which passes through the skin. The solutions should contain a sufficient number of ions, but should not be so concentrated as to irritate the skin or mucous membranes. One to 3 per cent solutions will be found sufficient.

As the quantities of chemicals introduced per milliampère minute are very small, fairly strong currents, from 10 to 100, or even more M.A., should be employed for twenty to forty minutes. Currents of a few M.A. only for five to ten minutes will be found quite insufficient in most cases. To produce the currents, twenty-four to forty Leclanché cell batteries, with a good collector, or a "Pantostat," No. 2005, or a switchboard to control the continuous current from the main, should be used. A milliampèremeter is necessary to measure the strength of the currents. The ordinary small disc electrodes, covered with one layer of chamois leather only, are not suitable, it is important that there should be a *thick* layer of absorbent material between the skin and the metal electrodes. Several layers of lint, or a thick piece of felt, or some absorbent cotton wool, is to be soaked in the solution and placed on the spot to be treated ; a flexible metal electrode of tin or copper is pressed on to the absorbent material, or fastened with laces. Round an arm or a leg a binder which has been soaked previously in the solution can be wrapped round in several turns, and metal gauze can be fastened on it. Lint or binders may be used repeatedly, but should be washed out well after use to remove all traces of the chemicals used, and the ions which have been introduced in them from the body and from the metal electrode.

In cavities like the ear, urethra, vagina, rectum, etc., irrigators can be used to introduce the solutions, and contact can be established with a small silver wire projecting inside the irrigator for a short distance, and fitted with a terminal outside (see Electrodes, Nos. 585 and 573).

It is important that the absorbent material should make a *good, even* contact ; if only one edge presses, or if it were partly dry, the current will concentrate on the parts making better contact, and will cause irritation or pain to such an extent that the treatment may have to be suspended for some time. If the absorbent material has been well moistened, has a reasonable thickness, and is pressed evenly on to the skin, the current can *gradually* be increased to considerable strength without causing pain or serious discomfort.

The chemicals become evenly distributed in the minute cells near the electrode, and for this reason even small doses will have a more powerful effect near the spot where the application was made than much larger doses which are swallowed or injected and which may produce undesired effects in the stomach, etc., before reaching the spot where their action is desired. It is, however, not possible to concentrate the effect of drugs introduced by electric currents on parts some distance away from the electrodes, because when the ions reach larger blood vessels, they are washed away and can soon be traced in the urine, saliva, etc. For this reason the treatment is most effective in all those cases where the parts to be treated are near the surface, as in skin diseases, or in treating wounds, ulcers, or when there is only a thin layer of tissue between the electrodes and bones ; it is easier to cure a gouty wrist, elbow, or heel, than a gouty hip joint or shoulder. The method is also useful in some affections of the eye.

To treat gout, lithium chloride is used at the anode, and uric acid can be found there some time after the current has been closed, as it has been attracted by the anode. Sodium salicylate can be introduced simultaneously from the cathode. Sodium salicylate is also very efficient in many painful affections, neuralgias, wounds, etc. Warts can be removed without leaving visible scars or cicatrices, by introducing magnesium sulphate (see *Archives d'Electricite medicale*, Dec. 10, 1911), with a current of 20 M.A. for twenty minutes three times a week. The introduction of the zinc ion is useful as an antiseptic, in boils, abscesses, in treating wounds, tuberculous fistulæ, rodent ulcer, anthrax, etc. Urethral strictures are resolved by treating them with olive-shaped metal electrodes connected with the negative pole ; the ions NA + and OH – are formed, and the latter tends to soften scar tissues. Strictures in the œsophagus have been treated with success in the same manner.

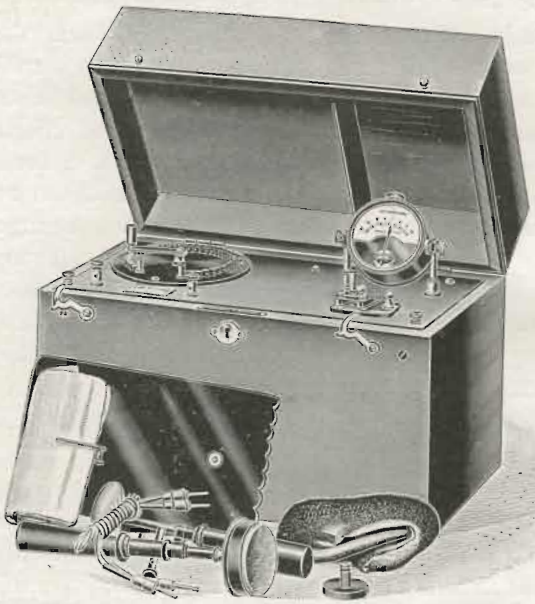
More details about these subjects will be found in :—

Electric Ions and their Use in Medicine, by Prof. Leduc ; translated by R. W. Mackenna, M.A., price 2s. 6d. In Lewis Jones' book on *Medical Electricity*, 6th edition, 1912. In the *Medical Annual*, 1912, pages 86 to 97, etc. Excellent results have been obtained by Dr. Lewis Jones in the treatment of rodent ulcer, etc., by this method (see *Lancet*, Oct. 28th, 1905, or *Brit. Med. Journal*, Feb. 16th, 1907). In the latter journal, of Aug. 15th, 1908, there is an article by P. L. Fenwick, M.D., recommending this method for the treatment of gonorrhœa. Dr. Sloan, of Glasgow, recommends it for gynæcological work in the *Lancet* of July 10th, 1909, and Dec. 23rd, 1910.

On pages 486–492 of the *Brit. Med. Journal* of Aug. 31st, 1912, will be found interesting papers by Dr. Lewis Jones, Dr. Samuel Sloan and others, about ionic medication in theory and in practice.

No. 610. The cost of a Complete Set, consisting of an 18-cell Leclanché battery, No. 116, with cords, handles, a set of 7 different electrodes suitable for ionic medication, and a milliampèremeter, No. 281, will be .. **£7 0 0**

This size battery is sufficient for all dental purposes, and for *some* skin diseases.



No. 612.

No. 612. To reach stronger currents for the treatment of larger areas, gouty and rheumatic cases, etc., a battery with a larger number of cells is preferable. A complete set, with a 32-cell battery, No. 118, milliampèremeter, No. 281, cords, handles and 7 electrodes, including 1 chain electrode, ½ yard metal gauze, safety pins with terminals, and ½ yard of pure felt or lint (*see* Fig. 612) is **£9 0 0**

ELECTRODES FOR IONIC MEDICATION AND ELECTROLYSIS.

In addition to the special electrodes mentioned below, the Electrodes Nos. 453, 455, 573, 585, 590, 710–713, *etc., can also be used for ionic medication.*

No. 620. Pure Lint, for ionic medication, per oz. .. .. **5d.**

No. 622. Flexible Metal Gauze, to be fastened over the lint, per yard .. **1/–**

No. 624. Safety-pin with Terminal, to make connection between the connecting cords and the metal gauze, each .. **6d.**

No. 630.

No. 632.

No. 638.

No. 630 Glass Vessel, with carbon rod, and porous clay cap, diameter 2½ ins., Fig. 630 .. .. **8/–**

No. 632. Cup of ebonite, with a spiral platinum wire, to make contact, Fig. 632. .. .. 9/-

No. 638. Large Electrode for cataphoresis, diameter 8 ins., consisting of a disc of aluminium over which parchment or a pig's bladder can be fastened, Fig. 638 .. **18/-**

No. 642. Dr. Meissner's Double Electrode, diameter 2 ins., Fig. 642 .. .. .. **16/-**

No. 643. Electrode, for applying ionic medication to vagina and uterus, consisting of ebonite cone with tap, silver wire, and rubber tube **8/-**

No. 644. Electrode, for the male urethra, Fig. 644 .. **15/-**

No. 642.

No. 644.

No. 645. Set of Dr. Lewis Jones' Electrodes, of pure zinc, consisting of 5 needles and 4 larger electrodes of different sizes, for the treatment of rodent ulcer **10/-**

No. 647. Dr. Lewis Jones' Electrode, made of copper rings, to fit the head of a child of about 10 years **16/-**

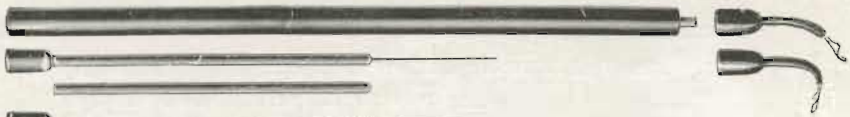
No. 648. $4\frac{1}{2} \times 6$ in. **8/-**

No. 649. $5\frac{1}{2} \times 11$ in. **11/-**

Other sizes can be made to order.

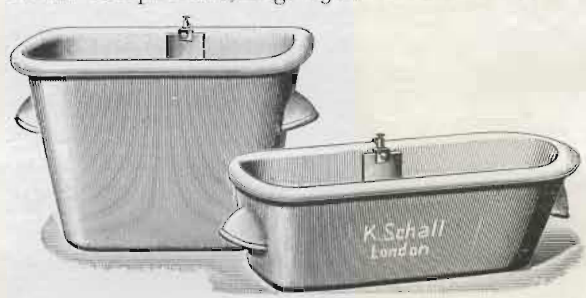
No. 650.

No. 650. Complete set of Ophthalmic Electrodes by Dr. Wirtz (see *The Ophthalmoscope*, Jan., 1911, "Iontophoresis in Eye Work") **£2 8 0**



No. 650*a*.

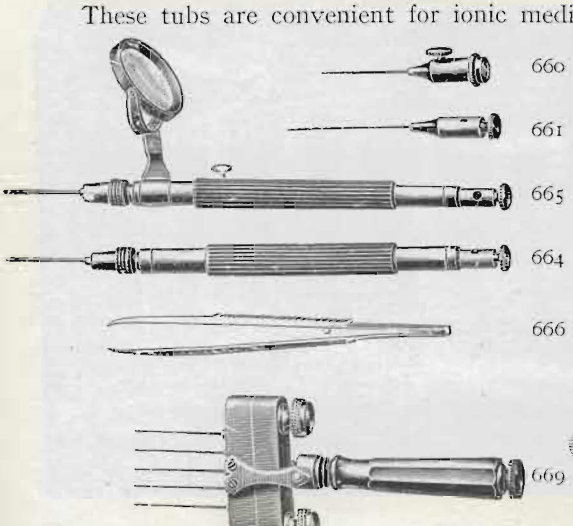
No. 650*a*. Electrode, for the electric sterilisation of teeth, and for dental cataphoresis, Fig. 650*a* £1 10 0

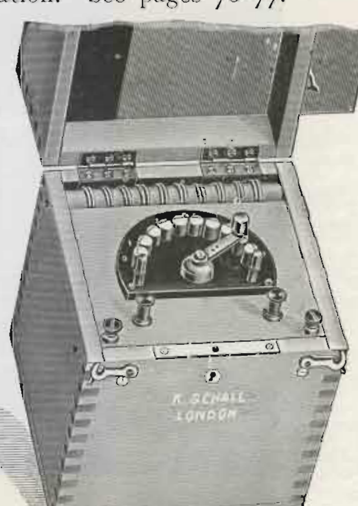


No. 652. No. 651.

No. 651.	Large tub, Doulton ware, for an arm-bath, with carbon electrode, Fig. 651	16/-
No. 651*a*.	Similar tub, of white porcelain	26/-
No. 652.	Large tub, Doulton ware, for a foot-bath, with carbon electrode, Fig. 652	18/-
No. 652*a*.	Similar tub, of white porcelain	30/-

These tubs are convenient for ionic medication. See pages 76–77.





No. 675.

No. 660.	Steel Needle with terminal, Fig. 660	1/6
No. 661.	Platinum Needle with terminal, Fig. 661	4/6

No. 662. Gold Needle **3/-**

No. 663. Lens as shown in Fig. 665, for magnifying the hairs; it can easily be attached to our needle-holders Nos. 664 or 665 .. **5/-**

No. 663*a*. Lens for epilation, to be worn on forehead .. **£1 15 0**

No. 664. Needle-holder for the reception of different needles, Fig. 664 .. .. **4/-**

No. 665. Needle-holder with interrupter, Fig. 665 .. **4/6**

No. 666. Forceps for epilation, Fig. 666 .. .. **2/-**

No. 663*a*

No. 668. 25 steel needles (No. 12) .. .. **-/6**

No. 669. Dr. Lewis Jones' multiple bipolar needle-holder, for treatment of nævi, Fig. 669 .. .. **15/-**

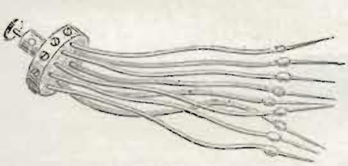
No. 675. Complete set for epilation, consisting of 9-cell battery with collector inserting the cells one by one (see Fig. 675), bracelet electrode No. 412, needle-holder No. 664, forceps No. 666, a packet of needles and connecting wires **£3 0 0**

Explicit directions for use are sent with this outfit.

Needles for destroying tumours, etc., with flat platinum points, and shafts insulated with india-rubber.

Nos. 676—679.

No. 676. Needle, 1 inch long **4/-**	No. 678. Needle, 3 inches long **5/-**
No. 677. ,, 2 inches long **4/9**	No. 679. ,, 4 ,, ,, **5/9**



No. 680.

No. 695.

No. 680. Electrode, holding 12 steel needles, Fig. 680 .. .. **8/-**

No. 682. Electrode, holding 12 platinum needles **£1 16 0**

No. 695. Voltolini's double needles, Fig. 695 .. .. .. **3/3**

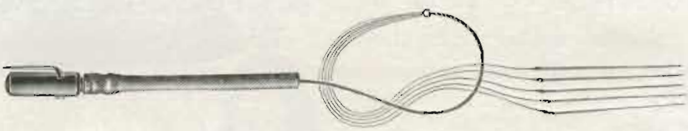
Nos. 685 and 686

No. 685. Steel Needles, with flexible spiral fitting into the holder shown on Fig. 680, each .. .. .. 9d.

No. 686. Platinum Needle, 0·5 mm. thick, with flexible spiral, folding into the holder shown in Fig. 680 .. .. 4/-

No. 690.

No. 690. Dr. Lassar's Multiple Needle, with 10 steel needles, Fig. 690 .. .. .. 7/3



No. 692.

No. 692. Prof. Kromayer's Subcutane Needles, Fig. 692 .. 7/-

No. 710.

No. 710. Bougie electrode, with Brodie's handle, for the treatment of strictures of the urethra, Fig. 710 . .. .. 8/6

No. 711.

No. 711. Similar Bougie, with 9 olives of different sizes, Fig. 711 16/-

No. 713.

No. 713. Similar electrode, very flexible, in metal case, Fig. 713 .. 14/6

746

747

747A

No. 746. Handle for the reception of uterine sounds, Fig. 746 .. 7/0
No. 747. Prof. Engelmann's aluminium Sound, Fig. 747 .. .. 2/9
No. 747*a*. Dr. Apostoli's Sound, of silver, Fig. 747*a* 9/0

No. 757.

No. 760.

No. 757. Vaginal Electrode, Fig. 757 .. .. 4/6
No. 760. Uterine Electrode, Fig. 760 .. .. 4/6

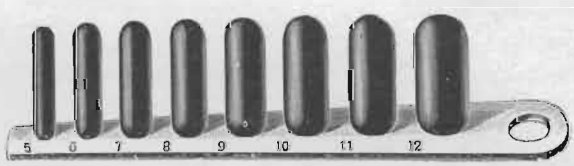
No. 789.

No. 790.

No. 789. Dr. Apostoli's double vaginal Electrode, Fig. 789 . . . . **15/-**
No. 790. Do., do., Electrode for the urethra and uterus, Fig. 790 **10/6**

No. 791

No. 791. Apostoli's Carbon Electrodes, Fig. 791 . . . . **7/6**



No. 792.

No. 792. Similar Electrode, with set of 8 carbon cylinders of different sizes, 5 to 12 mm., Fig. 792 . . . . **£1 0 0**

[*Copy of an unsolicited testimonial.*]

"DEAR SIR,

"Will you please send me one of your combined batteries, No 132, if you consider that this is a good form for general consulting-room use ?

"I have had many batteries from various makers, and I think the three I have had from you are much superior to any others I have seen of their kind, and also cheaper considering their workmanship.

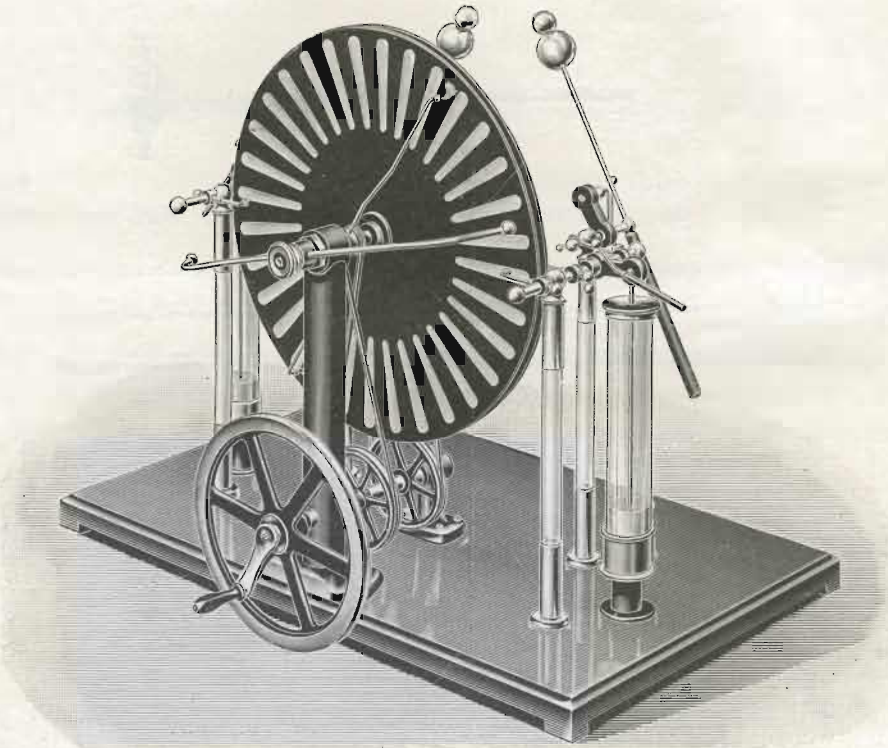
"Yours faithfully,

"FORBES FRASER."

"2, THE CIRCUS, BATH."

APPARATUS FOR FRANKLINISATION.

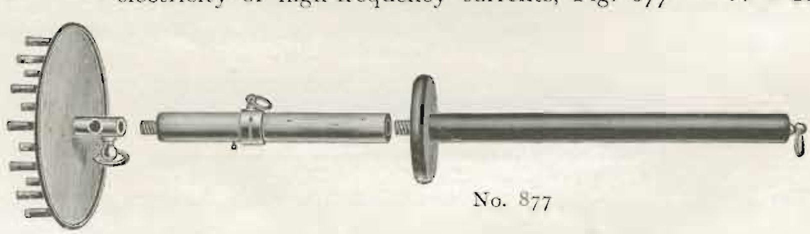
Of all the various constructions of static machines, the Wimshurst machines have been found to be the most reliable.



No. 806.

WIMSHURST MACHINES.

No. 806.	With two ebonite plates, diameter 22 in. ..	£13 10 0
No. 807.	,, four .. .. ,, ,, ..	20 0 0
No. 808.	,, eight ,, ,, ,, ,, ..	38 0 0
No. 860.	Large insulating platform, 40 × 28 in., on strong feet of glass	2 5 0
No. 870.	Electrode, with wooden ball or point	0 8 6
No. 871.	,, ,, metal ,, ,, ...	0 8 6
No. 877.	Long insulating handle of ebonite, for electrodes for static electricity or high-frequency currents, Fig. 877 ..	0 11 0



No. 877

No. 879

No. 880

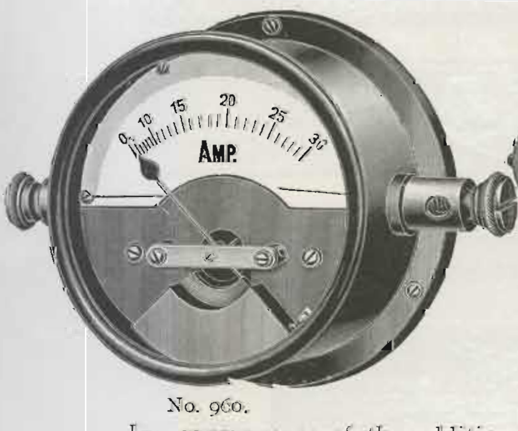
No. 879. Multiple point electrode, Fig. 879 .. .. **12/6**

No. 880. Bowl for the head, on insulated stand, Fig. 880 .. .. .. **50/-**

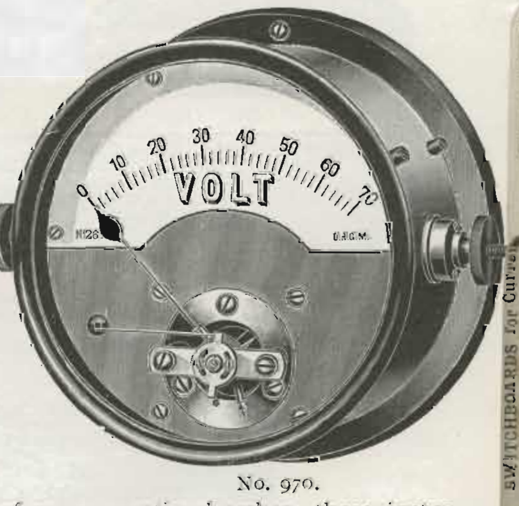
No. 885. Two highly insulated cables, for static electricity or high-frequency currents .. **10/-**

Electric motors suitable to drive static machines vary from £**6** to £**9**, including rheostat.

ELECTRO-MAGNETIC VOLT AND AMPÈREMETERS.



No. 960.



No. 970.

In consequence of the addition of a pneumatic chamber, these instruments are practically dead beat.

Diameter 4 ins. ; diameter of the base 5 ins.

Price of volt or ammeter for continuous current	£1 10 0
,, ,, ,, alternating ,, ...	1 8 0

No. 950. Voltmeters are supplied reading up to 3, 5, 20, 50, 100 or 130 volts.
No. 960. Ampèremeters, *Fig.* 960 ,, ,, 1, 5, 10, 20, 40 or 50 amps.

DEAD BEAT VOLT AND AMPÈREMETERS, for Continuous Current.

(MOVING COIL OR D'ARSONVAL TYPE.)

No. 970. **Voltmeters**, *Fig.* 970—

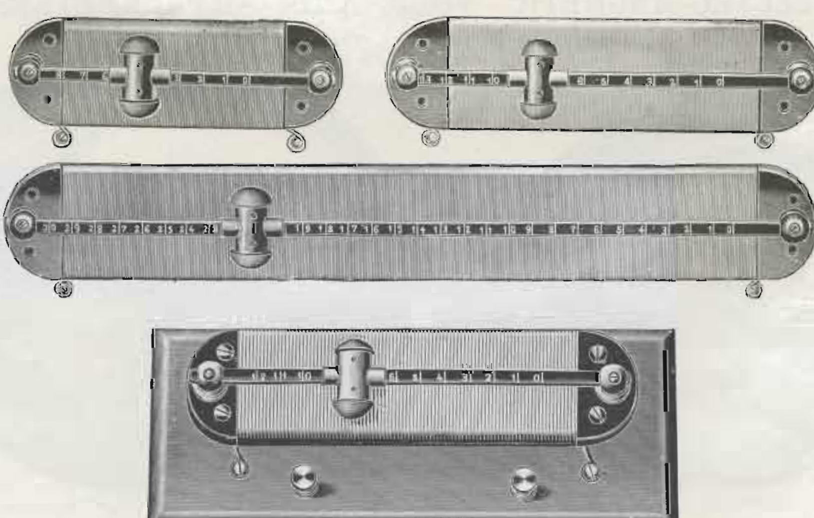
Reading up to	5	30	50	100	130	200	250 volts.
Diameter, 5 ins.	**45/-**	**46/-**	**48/-**	**50/-**	**50/-**	—	—
,, 8 ins.	**56/-**	**56/-**	**56/-**	**57/-**	**58/-**	**60/-**	**62/-**

No. 980. **Amperemeters**—

Reading up to	1	5	10	20	50	100 ampères.
Diameter 5 ins.	**45/-**	**45/-**	**45/-**	**48/-**	**50/-**	—
,, 8 ins.	**56/-**	**56/-**	**56/-**	**56/-**	**56/-**	**56/-**

RHEOSTATS.

With Sliding Contact, wound on Slate Cores.



Nos. 982 to 988.

No. 982.	Length ..	5½	7½	9½	14 inches.
	Resistance ..	0·3	0·4	0·5	— ohms.
	Current ..	12	17	20	— ampères.
	Price ..	**19/–**	**22/–**	**24/–**	
No. 984.	Resistance ..	4	5	5	7 ohms.
	Current ..	3	4	6	6 ampères.
	Price	**16/–**	**18/–**	**20/–**	**25/–**
No. 986.	Resistance ..	20	60	80	100 ohms.
	Current ..	1	1	1	1 ampères
	Price ..	**16/–**	**18/–**	**20/–**	**25/–**
No. 988.	Resistance ..	250	500	1000 ohms.	
	Current ..	0·1	0·2	0·1 ampères.	
	Price ..	**20/–**	**27/–**	**30/–**	

If mounted on polished board, with terminals, the prices are increased by 2/9.

None of these rheostats can be connected directly with the current from the main, but many of them can be used with 100 to 250 volt currents if an incandescent lamp or a motor is connected in series with the rheostat.

We have quoted the maximum number of ampères for which the rheostats are suitable; these figures are approximately correct only if the rheostats are not switched on for longer than about fifteen minutes at a time.

RESISTANCES FOR CHARGING ACCUMULATORS FROM THE MAINS.

No. 995.

No. 995. Resistance Lamp-holder, with terminals, for connection with accumulators, Fig. 995 .. **£0 6 0**

This Lamp-holder is inserted into an ordinary Edison lamp-holder, and is suitable for lamps up to 60-candle-power. The poles are ascertained by means of pole-finding paper.

No. 997. Board with 4 lamp-holders, switch, fuse, and terminals to connect with accumulators **1 5 0**

This board is suitable for currents up to 5 ampères on a 200-volt supply.

No. 999. Book with pole-finding paper .. **0 1 6**

The negative pole makes a red stain on the moist paper.

For Rheostats for Galvanisation, etc., see also Nos. 306–328 and 1820–1850.

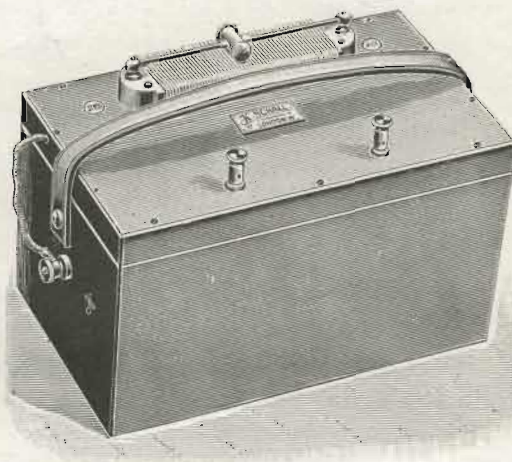
For Rheostats for Spark Coils, see also Nos. 2672–2678.

For Rheostats for Cautery, etc., see also Nos. 2000–2050.

ACCUMULATORS.

(See also pages 25-27.)

No. 916.



No. 922.

No. 1010.	4-Volt Accumulator, for surgical lamps only, capacity 15 ampère hours, in leather case	£1 8 0
	Size $4\frac{1}{2}\times2\frac{1}{2}\times6\frac{1}{4}$ in., weight about 3 lbs.	
No. 1012.	8-Volt Accumulator, for surgical lamps only, capacity 15 ampère hours, in polished mahogany case, **including rheostat,** Fig. 916	3 0 0
	Size $4\frac{1}{2}\times8\frac{1}{2}\times6$ in., weight 15 lbs.	
No. 1015.	4-Volt Accumulator, for cautery burners, capacity 45 ampère hours, in polished walnut case, **including rheostat**	3 10 0
	Size $7\frac{1}{2}\times7\times6\frac{1}{2}$ in., weight 24 lbs.	
No. 1018.	8-Volt Accumulator, for cautery or surgical lamps, capacity 45 ampère hours, in polished walnut case, **including rheostat,** Fig. 922	5 12 0
	Size $7\frac{1}{2}\times12\times7$ in., weight 45 lbs.	
No. 1020.	12-Volt Accumulator, for surgical motors, spark coils, cautery, or surgical lamps, capacity 45 ampère hours, in polished walnut case, **including rheostat** ..	7 12 0
	Size $7\frac{1}{2}\times18\frac{1}{2}\times6\frac{1}{2}$ in., weight 60 lbs.	
No. 1024.	12-Volt Accumulator, in teak case, capacity 50 ampère hours, **without** rheostat	6 9 0

Other sizes or single cells can be supplied to order.

BICHROMATE BATTERIES FOR GALVANIC CAUTERY & FOR WORKING SPARK COILS.

(*See also pages 22–24.*)

*The Batteries marked * may also be used for lighting Surgical Lamps and driving Surgical Motors.*

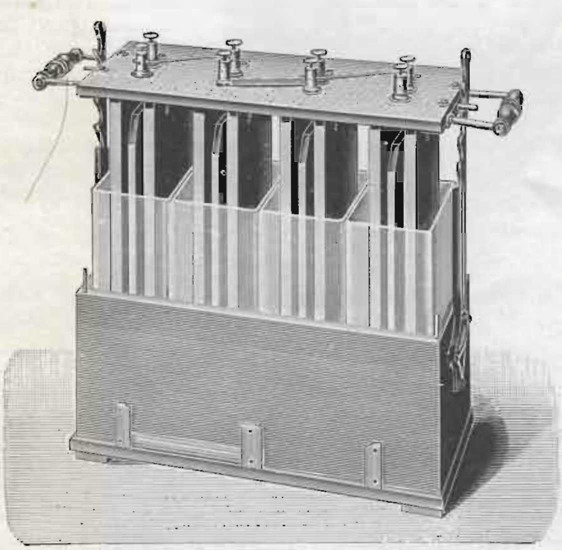
Batteries with two cells suffice for eye operations with galvanic cautery: for all other operations where galvanic cautery may be applied, four cells are required. Batteries with six or more cells are supplied, partly to enable the operator to double the constancy of his cells by connecting them up parallel, and partly for making the batteries useful for surgical lamps and for spark coils.

SIMPLE BATTERIES,

IN OAK CASE, FOR HOSPITALS, &c.

Each cell gives a current of over 30 ampères.

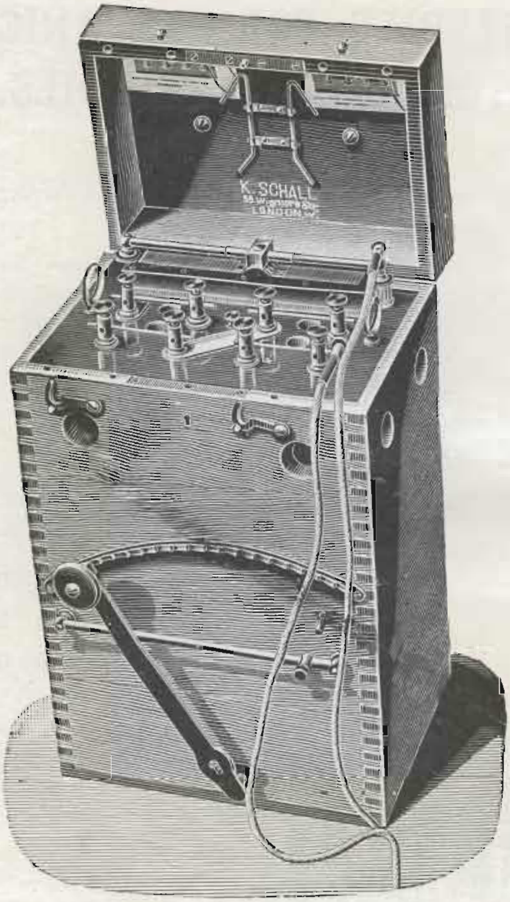
*No. 1035.	4 cells	.. ..	£4 0 0
*No. 1037.	8 ,,	.. ..	6 10 0
*No. 1039.	12 ,,	.. ..	9 0 0



No. 1035.

The battery No. 1039 may be used for spark coils, provided that it is supplied with larger glass vessels, measuring $4\frac{1}{2} \times 7 \times 9$ ins. each. Price of No. 1039 with larger cells **£11 0 0**

The prices include connecting cords. Rheostat for any of the above batteries, extra **18/-**.



No. 1040.

SCHALL'S PORTABLE CAUTERY BATTERY,

In Oak Case, with rheostat and cords.

*No. 1040. 4 cells, $7 \times 9\frac{1}{2} \times 15$ ins. Weight, 24 lbs.,
Fig. 1040 .. **£5 15 0**

*No. 1042. 6 cells **8 5 0**

The 6-cell battery is provided with a current collector in addition to the abovementioned accessories.

There are now about 900 batteries No. 1040 and No. 1042 in use in Great Britain and the Colonies, the best proof of their practical construction and reliable working. These batteries can be used equally well for cautery and for light, and they may be used to a limited extent for electrolysis, for removing hairs, destroying nævi, etc.

The acid is contained in strong ebonite vessels, pressed out of one piece. The ebonite cell can be moved up and down by means of a handle on the outside of the battery, and can be fixed at any elevation. A 4-cell battery keeps a platinum burner incandescent for about thirty minutes, and requires for its filling half a gallon of acid solution.

Copy of an unsolicited testimonial :—

Dear Sir,

Please send me six new zincs for the cautery battery (1042) I bought five years ago, It is a first-rate battery, and never has had "a day's illness"__unlike most electrical plant.

Yours faithfully,

John K. Murray.

Whittlesea, Cape Colony.

One pair of Cords for cautery .. ..each	5/9
Spare Zincs for batteries Nos. 1040 and 1042, consisting of 10 parts of zinc and 1 part of mercury, weight 1 lb. 12 ozs.	3/-
One pair of Carbons	7/-
Ebonite vessel for 4-cell battery	21/-
Ditto ditto 6-cell do. .. .. ,,	29/-
Acid, ready mixed, for charging the batteries Nos. 1035–1042, per gall.	3/6

Accumulators for cautery and spark coils will be found on page 75. For Rheostats and Transformers for utilizing the currents from dynamos for cautery and spark coils, see Nos. 2000-2050, and 2672-2678.

We have supplied Batteries Nos. 1040 and 1042, amongst many others, to :—

The War Office, The Crown Agents for the Colonies, to the Governments of India, Natal, New Zealand, etc.

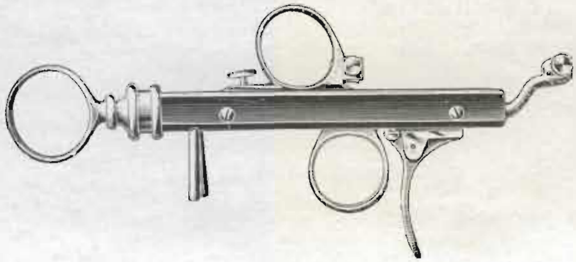
St. Bartholomew's, Charing Cross, Guy's, St. Peter's, St. Thomas's, Great Northern, London, St. Mary's, and Westminster Hospitals ; Lock Hospital ; Hospital for Diseases of the Heart and Paralysis, German Hospital, Victoria Hospital for Children, Central London Ophthalmic Hospital, Royal Hospital for Diseases of the Chest, etc.

Royal Infirmaries, Bristol, Glasgow, Windsor, Edinburgh ; Western Infirmary, Glasgow ; Queen's Hospital, Birmingham ; Bristol Eye Hospital ; Kent County Ophthalmic Hospital, Maidstone ; Infirmary, Wolverhampton ; Eye and Ear Hospital, Liverpool ; Eye and Ear Infirmaries, Southampton and Bath ; Ear and Throat Hospital, Birmingham ; General Infirmaries, Leeds and Sheffield ; Children's Hospital, Pendlebury ; Ear Institution, Manchester ; Throat and Ear Hospital, Nottingham ; Eye Hospital, Shrewsbury ; South Devon Hospital, Plymouth ; Children's Hospital, Sheffield ; Eye Hospital, Oxford ; Hospital for Sick Children, Newcastle ; Grimsby and District Hospital ; Sanatorium, Weymouth ; Wolverhampton and Staffordshire Infirmary ; Manchester and Salford Hospital ; Royal Sussex County Hospital, Guildford ; Ripon Hospital, Simla ; Medical College, Lahore, etc. And

To over 900 Medical Men.

INSTRUMENTS FOR GALVANIC CAUTERY.

The "Universal" Handles can be used for burners *and* snares.
The "Simple" Handles can be used for the burners *only*.

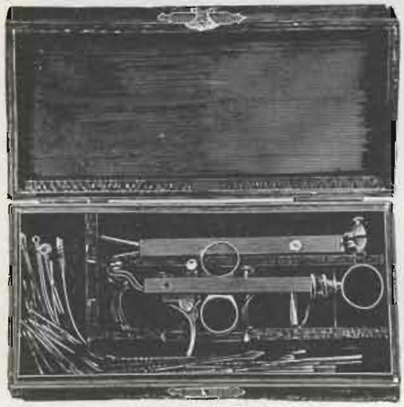


No. 1100.

No. 1100. Universal Handle, by Dr. Schech, Fig. 1100 .. **£1 7 0**

No. 1101.

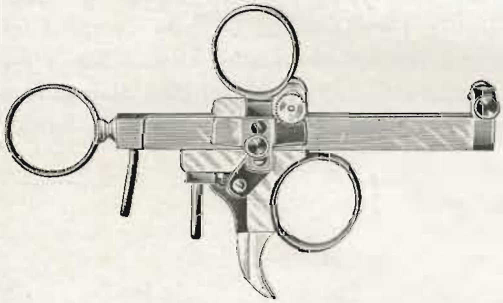
No. 1101. Simple Handle, by Dr. Schech, Fig. 1101 .. .. **0 14 0**
No. 1102. Set of Simple Handle and 3 different burners, in case **1 4 0**



No. 1104.

No. 1103. Set of Universal Handle, six different burners, two ligature tubes, and one porcelain burner, platinum wire for one loop, and steel wire for twelve loops **£3 10 0**

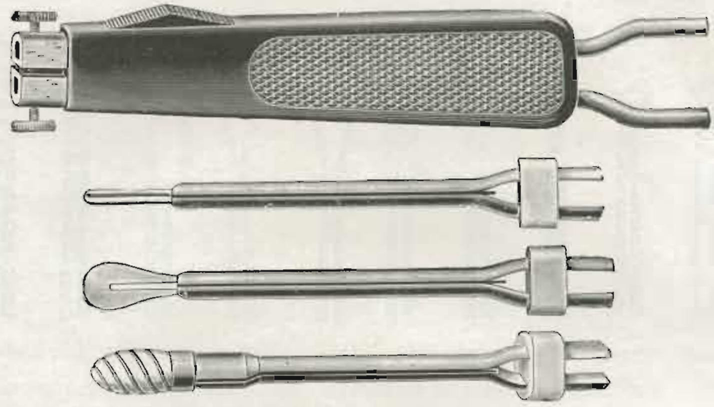
No. 1104. Schech's Universal Handle and Simple Handle, with ten platinum burners, two ligature tubes, two porcelain burners, platinum and steel wire, in case, Fig. 1104 .. **£4 12 0**



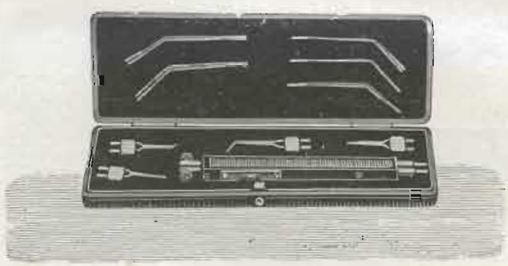
No. 1112.

No. 1112.
Universal Handle, by Dr. Kuttner.
Fig. 1112 .. **£1 16 0**

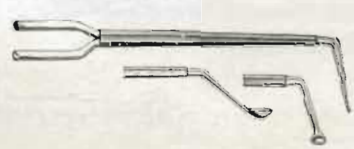
No. 1114.



No. 1114. Cautery Handle, Fig. 1114, suitable for burners requiring up to 50 ampères (for gynæcological operations) £1 14 0
Point or knife-shaped platinum burners for this handle (see illustration) .. .. .. each 1 4 0
Porcelain burner (see illustration) .. .. ,, 1 6 0
One pair of extra stout cables for handle No. 1114 .. 0 12 9



No. 1116.

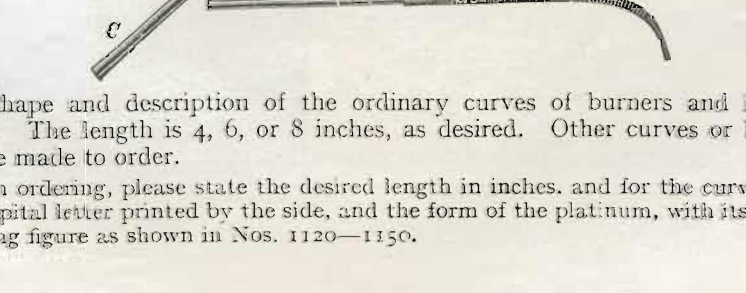


No. 1117.

No. 1116. Handle for eye operations, with five burners, in case, by Prof. Sattler-Nieden, Fig. 1116 .. .. £1 10 0

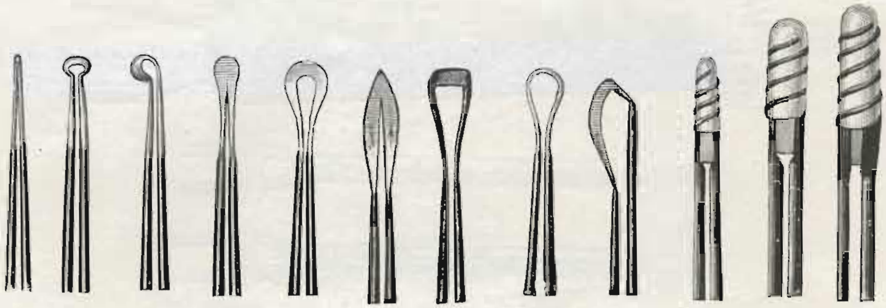
No. 1118.

No. 1118. Handle for small burners, Fig. 1118 .. .. 0 15 0



Shape and description of the ordinary curves of burners and ligature tubes. The length is 4, 6, or 8 inches, as desired. Other curves or burners can be made to order.

In ordering, please state the desired length in inches. and for the curve quote the capital letter printed by the side, and the form of the platinum, with its accompanying figure as shown in Nos. 1120—1150.



1120 1122 1123 1125 1126 1131 1132 1133A 1137 1150 1151 1152

Shape and numbers of the burners: Nos. 1120—1134 platinum, 1150—1151 porcelain.

Prices of the burners: Nos. 1120—1137, 3/3; 1150—1152, 7/-; ligature tubes, 3/6.

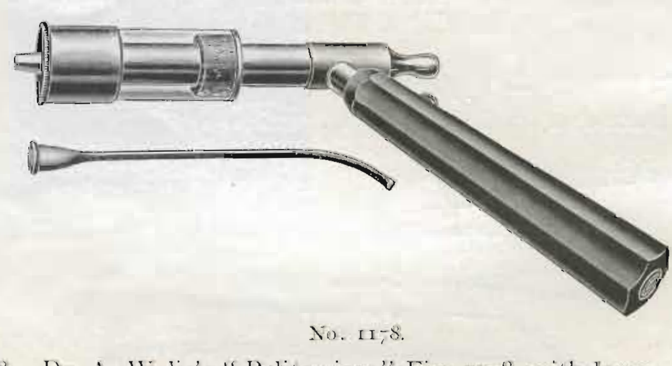
The burners 1120—1133 require 15 to 18 ampères and 4 to 10 volts.

The eye and ear burners require only 8 to 10 ampères.

Platinum wire for one large loop, 0·35 mm. thick, 46 ctm. long ..	£0	11	0
Steel wire, 0·3 or 0·4 millimetre thick, for six loops	0	1	0
Cases for cautery instruments	0	4	0

No. 1174.

No. 1174. Micro hot air burner for dermatological purposes, with two silver nozzles of different sizes, Fig. 1174 — 2 6 0



No. 1178.

No. 1178. Dr. A. Wylie's "Politzeriser," Fig. 1178, with large double bellows for same £3 0 0

This apparatus was made by us to the design of Dr. Wylie, to treat the Eustachian tube with hot air. It is to be connected with a cautery accumulator, or transformer, or pantostat, to make the platinum spiral incandescent; it is attached to a Eustachian catheter, and air is pumped in by means of a double bellows.

BATTERIES FOR ELECTRIC LIGHT.

(*See also page* 27–28.)

In order to make the lamps which are described on the following pages incandescent, batteries of 4 to 10 volts have to be used, or else the current from the main has to be reduced by means of a resistance or a transformer. About these latter instruments, see Nos. 2000—2067.

The most suitable batteries are **Accumulators** (see page 25 and Nos. 1010—1024), or **Bichromate Batteries** (see Nos. 1035—1042), or **Dry Leclanché Batteries** (see Nos. 1180—1188 below.)

Leclanché Dry Batteries for electric light.

No. 1181. Battery in leather bag, which may be fastened to a coat button, Fig. 1881 .. .. .. **£0 9 0**

No. 1181.

Size—2 in. wide × $5\frac{1}{2}$ in. long × 4 in. high, weight 22 oz.

The battery contains 3 dry cells giving 4·5 volt. It can be used for head lamps, urethroscopes, cystoscopes, and all other illuminating instruments which are fitted with 4-volt metal filament lamps. A rheostat, No. 1195, should be used to prevent the overheating of these delicate lamps

Leclanché Dry Batteries with rheostat and cords, in oak case.

		Volts.	Capacity in amp. hours.	Weight.	
No. 1185.	6 cells, $4 \times 5\frac{1}{2} \times 5\frac{1}{2}$ inches	9	5	4 lbs. ..	**£1 10 0**
,, 1186.	8 ,, $6 \times 9\frac{1}{2} \times 8$,,	12	15	15 ,, ..	**2 7 0**

No. 1186.

New cells for the batteries—

No. 1185 ..	each	**0 2 0**
,, 1186 ..	,,	**0 2 6**

No. 1189. Connecting Cords, Fig. 1189, for illuminating instruments, $4\frac{3}{4}$ feet long **£0 5 9**

,, 1189*a*. Similar Cord, $6\frac{1}{2}$ feet long **£0 6 6**

SWITCHBOARDS for Current from Main. LIGHT THERAPY. X-RAY APPARATUS

No. 1189.

No. 1195. Special Rheostat for very small lamps, Fig. 1195.

No. 1195.

One end is to be fixed into the terminal of battery or transformer, and a connecting cord is attached to the other end £0 8 6

INSTRUMENTS FOR ELECTRIC LIGHT.

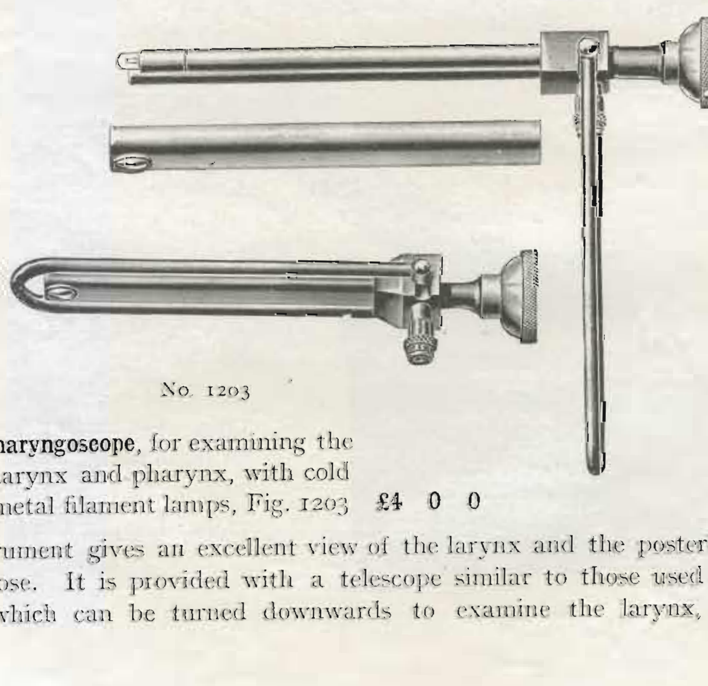
Where no special price is mentioned for extra spare lamps, it is .. 0 2 6

One spare lamp is included in the prices quoted for the instruments.

No. 1200

No. 1200. **Laryngoscope,** by Dr. Semon, with case, Fig. 1200 .. 1 16 0

This instrument can also be very advantageously used in dental operations. Further, the mirror can be removed, and the lamp, which has a very thin handle. can be used for the illumination of other cavities of the body.



No. 1203

No. 1203. **Pharyngoscope,** for examining the larynx and pharynx, with cold metal filament lamps, Fig. 1203 £4 0 0

This instrument gives an excellent view of the larynx and the posterior part of the nose. It is provided with a telescope similar to those used in cystoscopes, which can be turned downwards to examine the larynx, or

upwards to examine the posterior parts of the nose, etc. ; the metal cover can easily be sterilised.

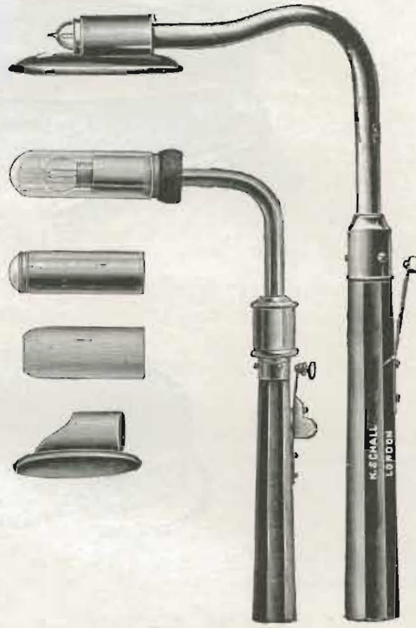
Special experience is not required to use the instrument.

No. 1206. **Tongue Depressor,** by Schall, with case and one spare lamp, Fig. 1206. It can also be used for making the antrum transparent.
£1 16 0

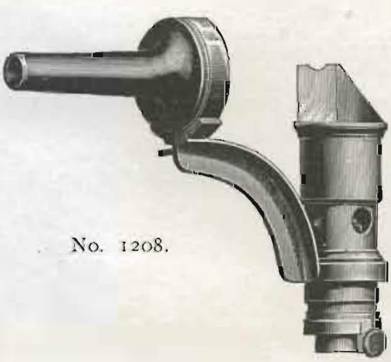
The ebonite spatula can be removed to be cleaned.

No. 1207. Hand Lamp, Fig. 1207,
£2 6 0

This lamp can be used as a hand lamp, or as a tongue depressor, or, with a bull's-eye lens, for making the antrum transparent.



No. 1207. No. 1206.



No. 1208.

No. 1208. Schall's **Otoscope,** fitted with incandescent lamp, case, spare lamp, and three ear funnels in case, Fig. 1208
£2 16 0

This apparatus gives a brilliant light, and allows free movement for the operating instrument.

No. 1210.

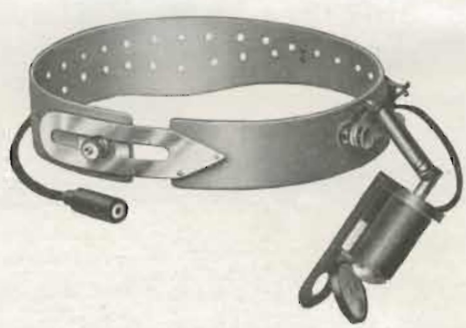
No. 1210. **Incandescent Lamp,** for vaginal speculum, with one spare lamp, Fig. 1210 .. .. .. **£1 9 0**

The lamp can be clamped to any speculum.

FOREHEAD LAMPS.

For the examination of mouth, pharynx, larynx, nose, ear, eye, rectum, vagina, and urethra.

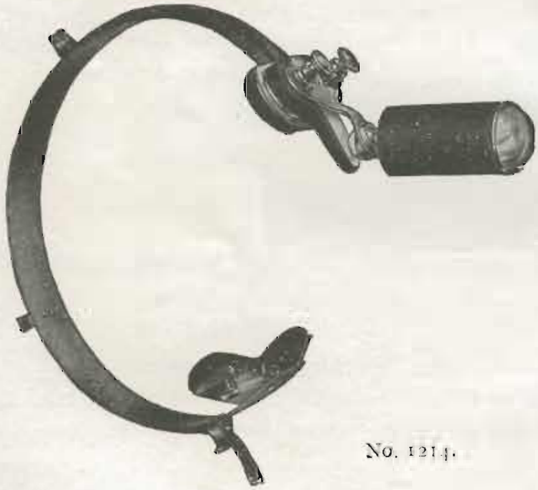
No 1212.



No. 1213.

No. 1212. Forehead Lamp, with concave mirror and lamp, with case and spare lamp, Fig. 1212 .. .. **£2 14 0**

,, 1213. Dr. Kirstein's Head Lamp, Fig. 1213, with perforated concave mirror, so that the eye looks parallel with the ray of light. This is of advantage for narrow passages like the ear or male urethra **2 4 0**



No. 1214. Forehead Lamp, with steel band, spare lamp and case, Fig. 1214 .. **£1 16 0**

No. 1214.

No. 1214*a*.

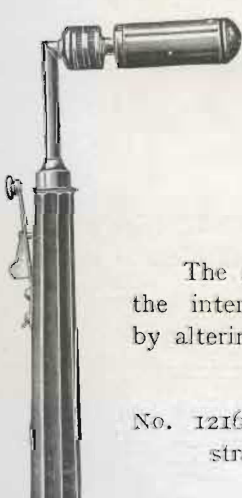
No. 1214*a*. Similar Lamp, with a band, which can be easily renewed, Fig. 1214*a* **£1 14 0**

The Lamps Nos. 1214 and 1214*a* are being used more frequently than all the other patterns taken together.

If the lens is pushed back as far as it will go, the illuminated area is large, and the light diffused; if it is drawn out the diameter gets smaller, but the light is more concentrated and intense. A parallel beam of light can be obtained with the lamp if desired. The light is bright and homogeneous.

The head lamps can be provided now with bulbs with metal filaments, requiring 4 volts only. The light is as intense as that obtained by carbon filament lamps of 8 volts.

The advantage of these low voltage lamps is that batteries with fewer cells can be used, 2 accumulator or 3 Leclanché dry cells are sufficient. The batteries are therefore cheaper and **lighter.** They can even be suspended on a button (see No. 1181) by the operator, and allow him a freedom of movement round an operating table, which is a little impeded when cords lead from a forehead lamp to a stationary battery or switchboard.



No. 1215.

No. 1215. Hand Lamp, with bull's-eye, for surgical operations, with case and spare lamp, Fig. 1215 .. **£1 15 0**

The diameter of the illuminated area and the intensity of the light can be regulated by altering the distance of lamp and lens.

No. 1216. The same Instrument, straight, Fig. 1216 .. **£1 10 0**

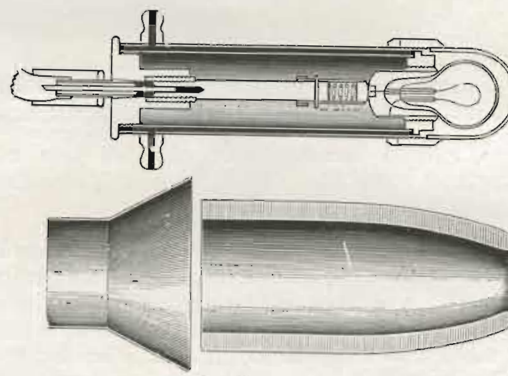
No 1216.

No. 1217.

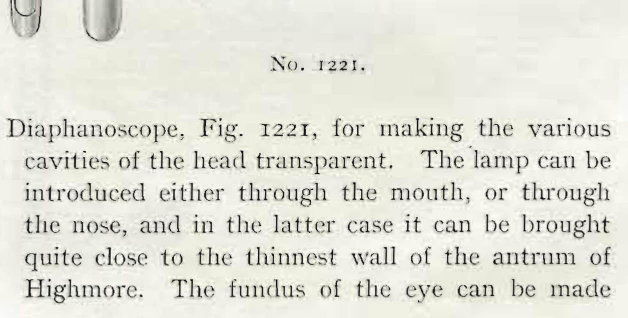
No. 1217. Forehead Lamp, Fig. 1217, with lamp to use the current from the main, and reflector, in case £2 10 0

This kind of forehead lamp is convenient to illuminate a larger area for operations, etc., but it is not suitable for narrow channels or cavities, as there is no lens to concentrate the light.

No. 1220. Lamp for trans-illumination of larynx, nose, temple, ear, etc., with india-rubber funnel and water cooling arrangement, Fig. 1220. £2 2 0



No. 1220.



No. 1221.

No. 1221. Diaphanoscope, Fig. 1221, for making the various cavities of the head transparent. The lamp can be introduced either through the mouth, or through the nose, and in the latter case it can be brought quite close to the thinnest wall of the antrum of Highmore. The fundus of the eye can be made

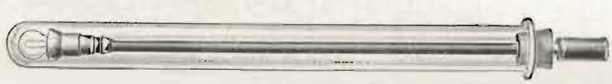
visible too, and pus, foreign bodies, and some tumours will show as dark shadows on the pupil. The greater part of the instrument is covered with an india-rubber tube, which can be boiled for sterilisation **£1 10 0**

Spare Lamps, of 4 volts, each **0 4 0**

No. 1222.

No. 1222. Dr. Einhorn's Gastro-Diaphanoscope, Fig. 1222, for making the stomach transparent **£2 8 0**

Spare Lamps, 6 to 8 volts, each **0 2 9**



No. 1223.

No. 1223. Lamp in glass tube, Fig. 1223, for examination during abdominal operations, and for making the rectum and posterior part of the vagina transparent .. **1 7 0**

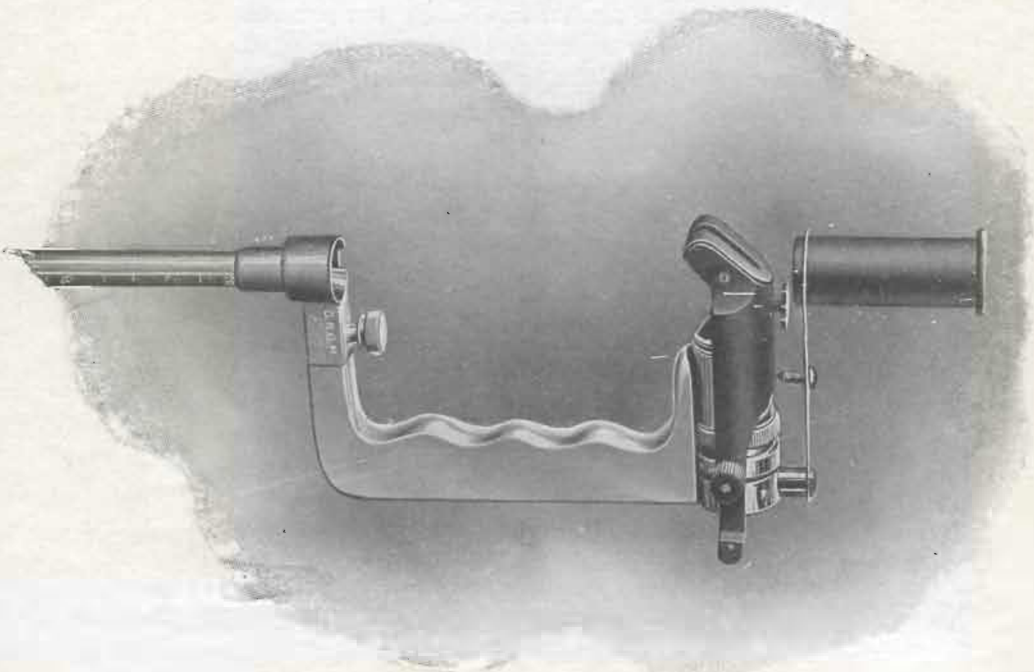
BRUENINGS' INSTRUMENTS
for direct Laryngo- Tracheo-Bronchoscopy and Œsophagoscopy.

A full description of this new method and its advantages, by M. H. Tilley, of University College Hospital, appeared in the *Lancet* of Nov. 7th, 1908: "Direct Examination of the Larynx, Trachea, and Æsophagus by Bruenings' Instrument."

The Apparatus consists of: (1) *The illuminating instrument.* (2) *Various bronchoscopic tubes.* (3) *Some forceps, etc., for operating through these tubes*

No. 1225. Complete set of instruments, as described below **£15 0 0**

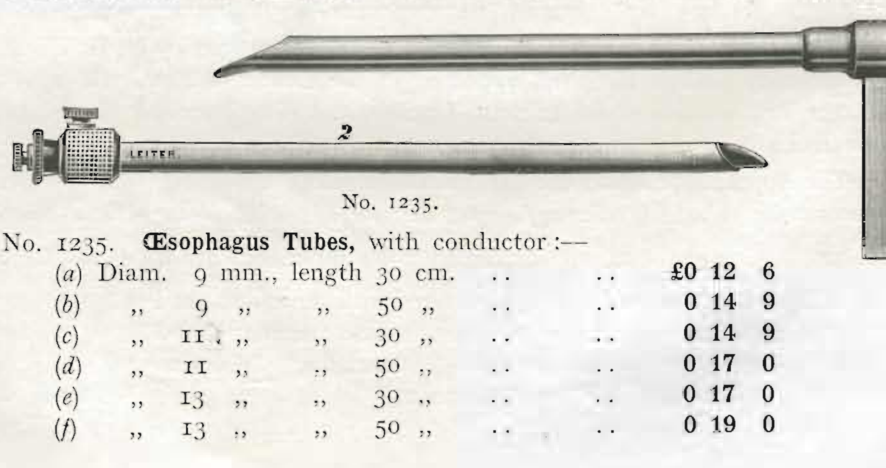
The set is arranged in a wooden case, covered with calico and lined with sailcloth, which can be washed, and includes stand with four glass bottles marked "Adrenaline," "Cocaine 10%," "Cocaine 20%," and "Paraffin" **1 6 0**



No. 1226.

This case contains :—

The illuminating instrument, with wires and one spare lamp ..	£4 4 0
5 double tubes of 5, 7, 8, 10 and 12 mm. diameter ..	5 0 0
1 inner tube for œsophagoscopy, 10 mm. diameter	0 10 6
3 special bougies as cannulas	0 11 0
1 extensible forceps for foreign bodies, with 5 interchangeable blades of various sizes for bronchoscopy	1 16 0
1 ditto, with two blades for œsophagoscopy	1 1 6
1 saliva pump, with three india-rubber tubes of different sizes	0 13 0
2 small hooks for foreign bodies	0 2 6
1 dozen cotton-wool carriers	0 5 0



No. 1235.

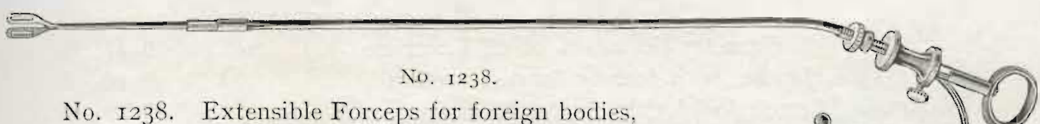
No. 1235. **Œsophagus Tubes,** with conductor :—

(a)	Diam.	9 mm.,	length	30 cm.	£0 12 6
(b)	,,	9 ,,	,,	50 ,, ...	0 14 9
(c)	,,	11 ,,	,,	30 ,, ...	0 14 9
(d)	,,	11 ,,	,,	50 ,, ...	0 17 0
(e)	,,	13 ,,	,,	30 ,, ...	0 17 0
(f)	,,	13 ,,	,,	50 ,, ...	0 19 0

No. 1236.

No. 1236. Extensible Tubes for œsophagoscopy or bronchoscopy, of 5, 7, 8, 10, 12 and 14 mm. diameter, each **£1 0 0**

No. 1237. Saliva Pump, with three tubes, 25, 35, and 50 cm. long **0 13 0**

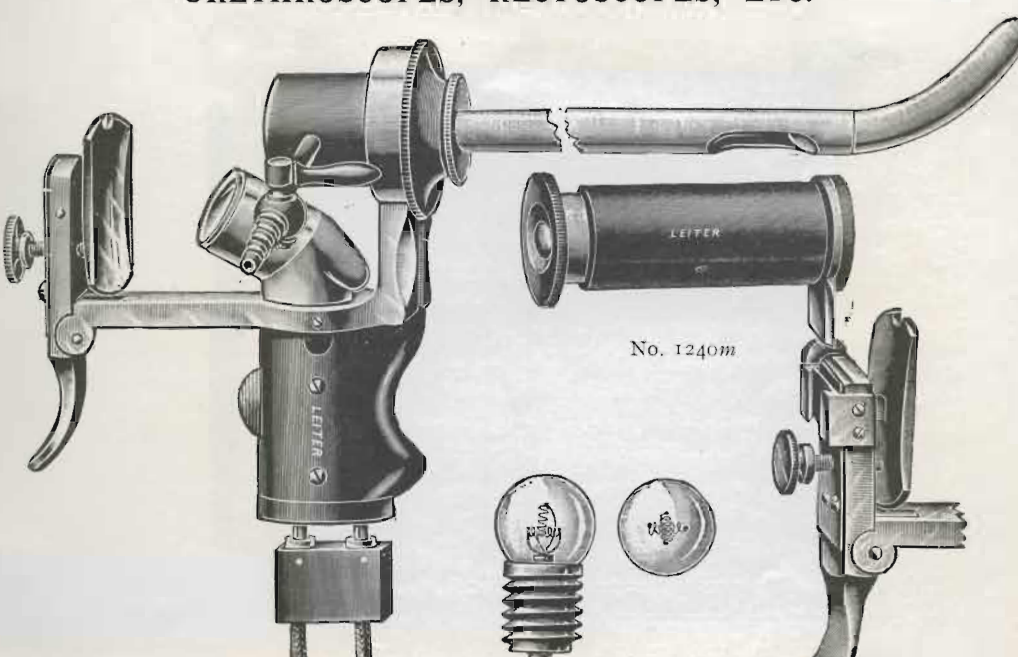


No. 1238.

No. 1238. Extensible Forceps for foreign bodies, with 7 interchangeable blades, 5 for adults and 2 for children .. **3 0 0**

No. 1239. Cocaine Spray **0 6 0**

URETHROSCOPES, RECTOSCOPES, ETC.



No. 1240m

No. 1240 No. 1240*i*.

No. 1240. New **Fenwick Leiter Panelectroscope,** Fig. 1240, with cord and 2 spare lamps **£2 11 0**

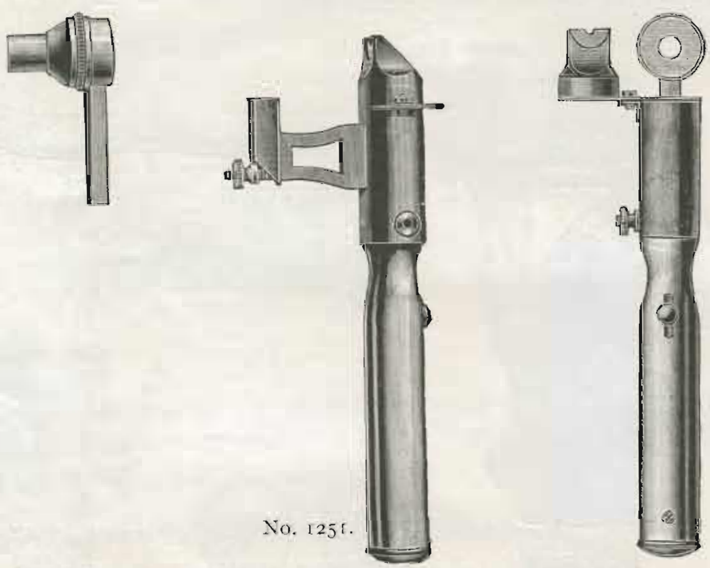
No. 1240*i*	Inflating Arrangement for above	£0 9 0
No. 1240*m*.	Magnifying Lenses	0 18 0
	Extra spare Lamps, each	0 4 0

This is a *universal instrument*, because it can be used equally well for the illumination of the *urethra*, the *rectum*, and *ear*, and it can also be used for the direct examination of the *œsophagus* (Bruening' method).

The metal filament lamps give a brilliant light, which is concentrated by means of a bull's-eye lens on a concave mirror. There is great freedom for the manipulation of the operating instruments, cotton holders, cautery burners, forceps, etc.

No. 1242.	Straight Urethral Tubes, diameter No. 18, 20, 22, 24, or 26 Charrière .. .. .. each	0 6 6
No. 1243.	Curved Tubes, for examining the coliculus seminalis (one of these tubes is shown in the illustration), diameter No. 24, 26 or 28 Charrière .. each	0 14 6
No. 1245.	Handle, with forceps for the urethra	0 16 6
No. 1246.	Cotton Wool Carriers, with screw thread ..	0 1 0
No. 1247.	,, ,, with forceps	0 1 6
No. 1249.	Wooden Case for the instrument, a set of tubes, etc., from .. .. 14/– to	1 1 0

Rectal Tubes fitting this instrument will be found under Nos. 1277 and 1296.
Œsophagus Tubes .. ,, ,, ,, Nos. 1235–1236.
Ear Tubes ,, ,, ,, ,, Nos. 1281–1282



No. 1251.

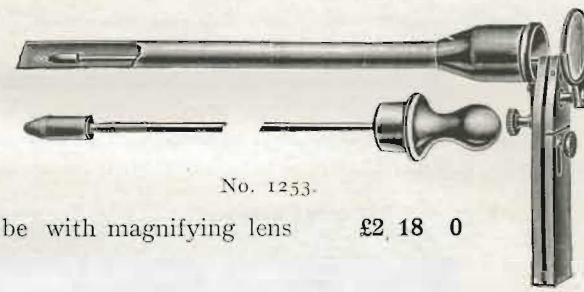
This also is a Universal Instrument, which, with suitable tubes attached, can be used for the illumination of the ear, nose, œsophagus, the bronchial tubes, rectum, vagina, and urethra.

The illustration on the left shows the instrument sideways, with the prism in position for illumination. The illustration on the right shows the prism swung back, and a urethral tube in position, in which a cotton holder or operating instrument may be introduced.

The Urethral Tubes, Nos. 1261 to 1266 .. .. ..
The Rectal Tubes, Nos. 1277 and 1289 .. ..
The Ear and Nose Tubes, Nos. 1281 and 1282 .. .. ..
The Œsophagus Tubes, Nos. 1235 *a* to *f* and 1236 .. ..
The Bronchoscope, No. 1230, and .. ..
The instrument for examining the female bladder, ...

Can be attached to No. 1251.

No. 1252.	Dr. Casper's Handle, with 3 urethral tubes, in case ..	£3 10 0
No. 1252*a*.	Similar Instrument, but with 6 urethral tubes and 2 cotton holders, in case	4 15 0
No. 1252*d*.	Dr. Casper's Handle, with 1 tube for the ear, one for the nose, 1 for the rectum, 1 for the vagina, 3 for the urethra, and 1 for œsophagus, in case ..	5 12 0



No. 1253.

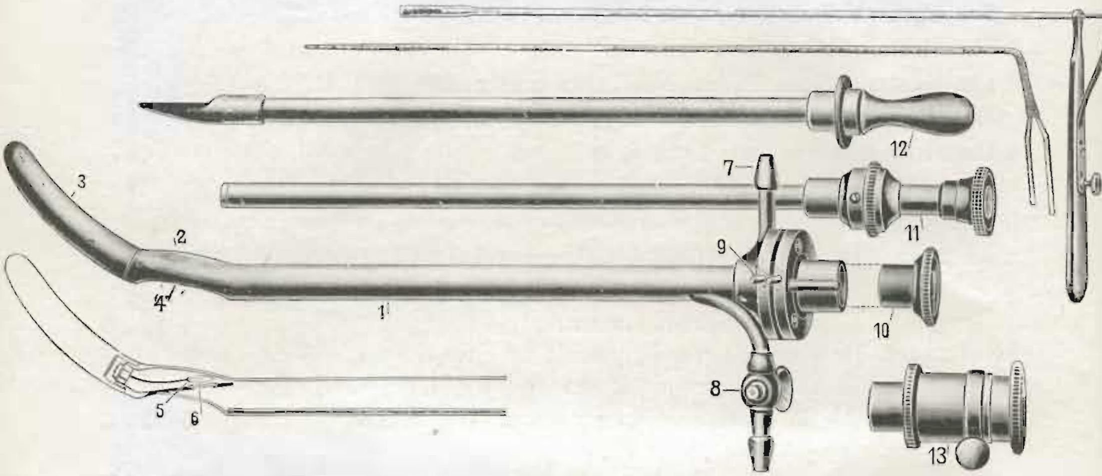
No. 1253. **Dr. Valentine's Urethroscope,** Fig. 1253, with small "cold" incandescent lamps, which are introduced through the urethral tube with magnifying lens £2 18 0

No. 1253A.

No. 1253*a*. **Dr. Valentine's Urethroscope,** lens, 3 urethral tubes, Rheostat No. 1195, cord, and 6 spare lamps, in case 4 14 0

The Lamps require 4 volts. Extra spare lamps 0 3 6

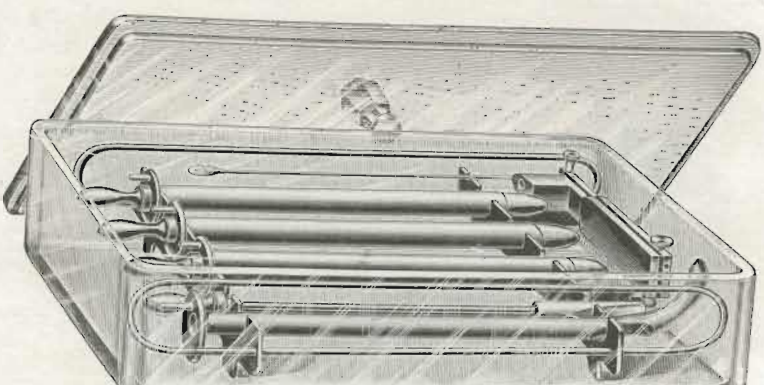
SWITCHBOARDS for Current from Main. LIGHT THERAPY APPARATUS X-RAY APPARATUS



No. 1256.

No. 1256. **Dr. Wossidlo's Urethroscope,** with cord, spare lamp, double bellows, brush and cautery burner, in case **£7 5 0**

Illustration and price of an Apparatus to take Photographs of the Urethra can be had on application.



No. 1258.

No. 1258. Glass Dish, to hold the urethroscope, with lid, Fig. 1258, with space for 6 straight and bent tubes .. **£1 0 0**

No. 1261.

No. 1261.	Urethral Tube, No. 16 French gauge, 3½ inches long, Fig. 1261	0	5	0
No. 1262.	Do. No. 18 French gauge, 4 inches long ..	0	5	0
No. 1263.	Do. No. 20 ,, ,, 4½ ,, ,, ...	0	5	0
No. 1264.	Do. No. 22 ,, ,, 5 ,, ,, ...	0	5	0
No. 1265.	Do. No. 24 ,, ,, 5 ,, ,, ...	0	5	0
No. 1266.	Do. No. 26 ,, ,, 5 ,, ,, ...	0	5	0

No. 1268.

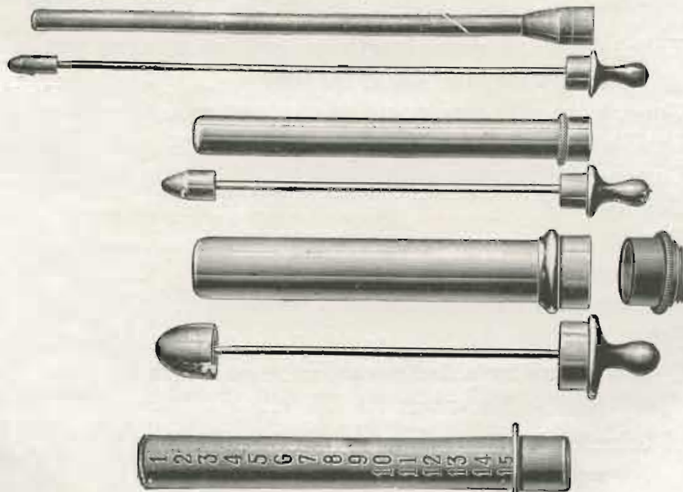
No. 1268. Glass Cylinder, with lid, to hold the sterilised urethral tubes, Fig. 1268 .. £0 10 6

No. 1272.

No. 1272. Tube for the prostate, Fig. 1272, diameter No. 23, 25, or 27 Charrière 0 15 0

No. 1276.

No. 1274. Cotton Holders for urethra 0 1 3
No. 1276. Glass Dish, with metal cover, for cotton holders .. 0 5 0



No. 1277.

No. 1277. Rectal Tube, with conductor, in three different sizes, Fig. 1277 .. .. each £0 4 6

No. 1278. Metal ring, to connect these tubes with the urethroscope .. .. each 0 3 0

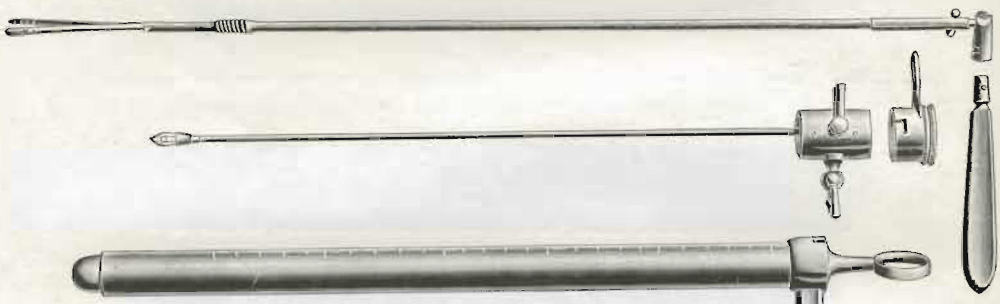
For illuminating the ear and nose, funnels of different diameter can be screwed on to the instrument.

No. 1281.

No. 1282.

No. 1281. Ear Funnel, in three different sizes, Fig. 1281 .. each 0 2 6

No. 1282. Tube for examining the nose, Fig. 1282 .. „ 0 3 6



No. 1296.

No. 1296. **Dr. Strauss' Rectoscope,** Fig. 1296.

This instrument can be introduced into the flexura sigmoidea while the lamp is burning, so that its *direction is under control.* The tube is provided with a window for inflation.

A.	Tube, diam. 20 mm., length 30 cm., with lamp and conductor, and *one spare lamp*	£1	18	0
B.	Tube, diam. 20 mm., length 35 cm., and *one spare lamp*	2	0	0
(*a*).	Double bellows for inflating the rectoscope	0	7	6
(*b*).	Cotton-wool carriers, with handle	0	10	0
(*c*).	Brush	0	2	9
(*d*).	Powder spray	0	9	0
(*e*).	Cautery burner	0	7	9
(*f*).	Wooden case for reception of a complete set ..	0	16	0
	Spare Lamps	0	2	9

No. 1297. **Prof. Schreiber's Rectoscope,** to be used with Casper's Handle No. 1252 .. .. 1 15 0

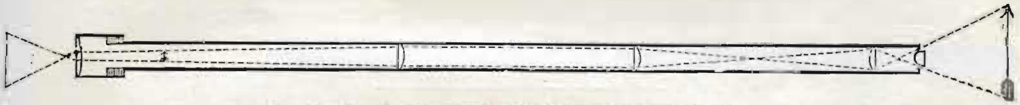
No. 1292*a*. **Schreiber's Rectoscope,** with Casper's handle, in wooden case, complete 6 0 0

CYSTOSCOPES.

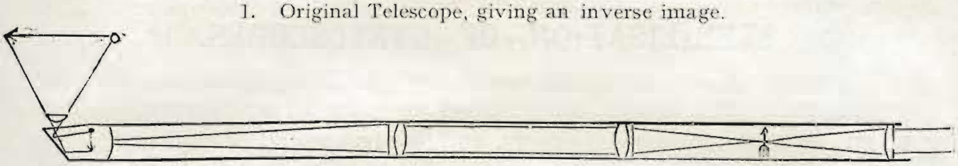
Cystoscopes were made originally at the suggestion of Prof. Nitze by J. Leiter, of Vienna. The first instrument was finished in 1880. Incandescent platinum wire had to be used at that time as source of light, and this made the instruments complicated; they came into practical use only after small incandescent lamps were available in 1886. The Cystoscopes were introduced in Great Britain by us in 1887, and Mr. Hurry Fenwick used them first, and described them in his work, *The Electric Illumination of the Bladder and Urethra.*

Since this time we made a speciality of cystoscopes, and generally have over a dozen different models in stock, so that customers have the advantage of being able to compare the merits of the various constructions, and especially the difference between the various optical systems existing at present, before making a choice.

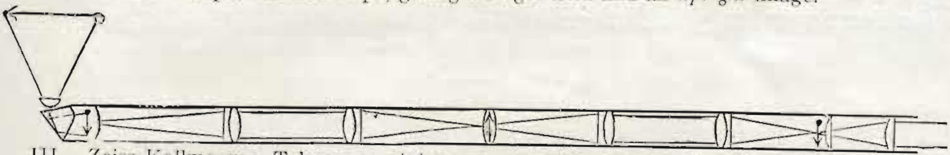
The optical part has made great progress during the twenty-six years since the first practical cystoscopes were brought out. The diagrams show the alterations :—



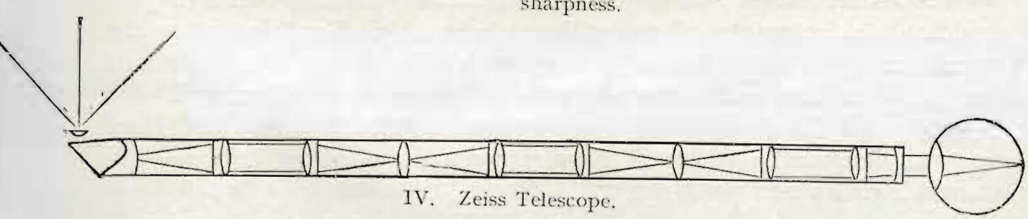
I. Original Telescope, giving an inverse image.



II. Improved Telescope, giving a larger field and an *upright* image.



III. Zeiss-Kollmorgen Telescope, giving an upright image of great brightness and sharpness.



IV. Zeiss Telescope.

The optical systems Nos. II. to IV. give an UPRIGHT image. This is a great convenience if catheters are to be introduced into the ureters, or if some operations, like the removal of a polypus, cauterisation, the enlargement of the orifice of the ureter, etc., have to be carried out. They give also a BRIGHTER PICTURE, so that more details become visible. This greater brightness has been reached by using a larger number of lenses, to avoid the losses due to the diffusion of light.

The cystoscopes with the optical systems Nos. III. and IV. are chiefly used by specialists ; the simpler systems, Nos. I. and II., are now much better than those supplied some years ago, and will be found quite sufficient for those surgeons and hospitals who want a cystoscope for examination only.

We can send to medical men or hospitals intending to buy a cystoscope, instruments with different optical systems for a few days, so that they can see the differences before deciding which to keep.

In comparing the optical systems of various cystoscopes, it is essential that instruments should be compared with one another which have the same length and diameter. A cystoscope of No. 22 Charrière will obviously give a brighter picture than a cystoscope of similar length but with a diameter of No. 16 only.

To compare the relative brightness and clearness of the image obtained with various systems, it is best to examine a small object at a distance of 2 ½ to 3 ctm. from the objective. An envelope with a penny postage stamp on it may be laid on a table, and a book 2½ to 3 ctm. thick on it to serve as a support, and to keep the instruments at a uniform distance. In examining the stamp, it becomes thus possible to compare the brightness, the amount of detail, etc., and, if a few concentric rings are drawn on the paper with a compass, the diameter of the field of view and the magnification can be measured and compared too.

The Zeiss system has the peculiarity of giving a sharp image only while the object is at a distance of about 25 mm. from the objective, whereas in the Zeiss-Kollmorgen system the picture is bright and sharp at any distance.

STERILISATION OF CYSTOSCOPES.

Those parts of the cystoscope which contain the electric connection, the lamp and the optical system, should never be *boiled* for sterilisation, because glass and brass do not expand evenly, and leakages would be the result ; the silvering of the prism may shrink, causing dark spots, and the insulation of the electric part may be damaged.

The cystoscope should be sterilised in the following manner :—

Immediately after use, it should be washed carefully in water, to prevent any pus, blood, or mucous matter, etc., becoming dry and adhering firmly to the instrument. It should then be carefully dried with sterilised cotton-wool, and some ether should be poured, with the help of a drop bottle, through any channels, for instance those for the catheters, etc. For this purpose the instrument has to be held so that the lamp end is uppermost, in order to prevent the ether from running over the lamp or prism, which might be damaged.

Before use, the instrument is rubbed once more with cotton wool and placed for twenty minutes in a solution of hydrargyrum oxycyanatum (1 in 1000) in a suitable glass vessel (see No. 1373). *All the parts which are to be introduced into the urethra are to be covered by this liquid.* The cystoscope is removed from this vessel only a few minutes before use. Any drops of the hydrargyrum oxycyanatum which may yet adhere to the cystoscope, and which might cause irritation in the urethra, will be removed if boric acid glycerine is poured over the instrument. Or else the cystoscope may be rinsed in a sterilised solution of boric acid before it is greased for use.

Those metal parts which can be removed entirely, operating knife, forceps, or Albarran's lever, may of course be boiled if desired.

The *Cystoscopes described and illustrated under Nos.* 1301 *to* 1314 *are made by Leiter*, who has the longest and far the largest experience in the manufacture of these instruments. On account of their excellent quality they are used by most specialists all over the world.

Metal filament lamps are used on account of the brilliant light obtained from them. The lamps are, however, fragile, and the spare lamps should be kept between cotton-wool, so that they cannot tumble about in the receptacle of the case. Four-volt batteries—either 3 dry Leclanché cells (see No. 1181), or else 2 accumulator cells—with a small rheostat, No. 1195, are sufficient to light them. Price of extra metal filament spare lamps, 4/- each.

If not specially mentioned otherwise, the prices quoted *include*: *one spare lamp*, a pair of *cords*, and a wooden *case* for the cystoscope.

No. 1301.

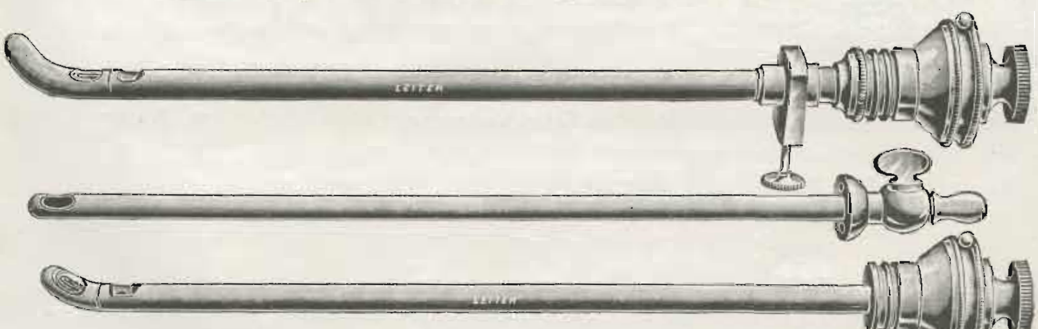
No. 1301. **Fenwick Leiter Cystoscope,** for examining the bladder, Fig. 1301 .. £4 2 0

This instrument can be supplied with diameter No. 21, 18, or 15 Charrière. The diameter of the field of view with an instrument of No. 21 diameter, and with a distance of 25 mm. between object and objective, is 32 mm.

No. 1301*u*. Similar Instrument, with upright image £4 12 6

No. 1302.

No. 1302. Cystoscope, with window, for examining the *posterior* part of the bladder, Fig. 1302 .. .. £4 2 0



No 1305.

No. 1305. **Irrigating Cystoscope**, Fig. 1305, with upright image, one straight and one curved lamp, and two spare lamps. Diameter No. 20 Charrière 6 0 0

This instrument is convenient when the examination becomes difficult on account of hæmorrhage. The catheter tube, diam. No. 20 Charrière, with mandrin, is introduced first. The irrigating tube with tap is then used to empty, wash, and fill the bladder; after this has been done the cystoscope, diameter 18 Charrière, with a *straight* lamp, is introduced through the catheter tube to examine the bladder. With a curved lamp the cystoscope alone can be used for the examination of children.

No. 1308.

No. 1308.	**Nitze Albarran Cystoscope,** with arrangement to introduce one catheter into the orifice of the ureter. With upright image, diameter No. 23 Charrière, cords, case, and 2 spare lamps ..	£7 3 0
No. 1309.	Similar Instrument, for the introduction of two catheters, Fig. 1309, diameter 24 Charrière ..	8 0 0

The Albarran lever can be removed for sterilisation after the lamp has been unscrewed half a turn.

The *Cystoscopes illustrated and described under Nos.* 1321–1351 *are our own patterns.* The quality and workmanship are of the highest grade.

The lamps require 7 volts; they are silvered at the back to increase the illuminating power.

Cords, case, and **one spare lamp,** are *included* in all the prices quoted below

No. 1321.	**Nitze's Cystoscope,** Fig. 1321, for examining the bladder	£4 2 0

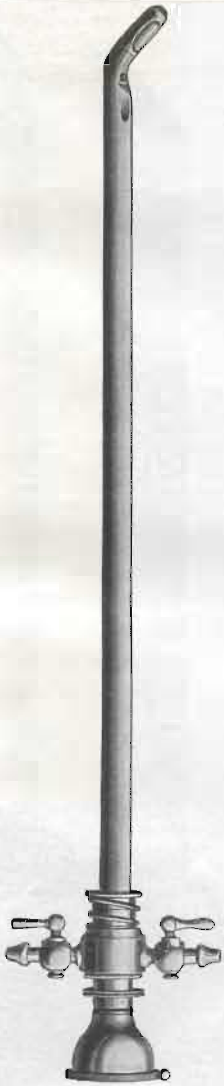
If the distance between object and lens is 35 mm., the objects appear in natural size.

The instruments Nos. 1321 to 1321*z* can be supplied with a diameter of No. 12 15, 18, 21 and 22 Charrière. If not otherwise ordered, No. 21 will be supplied, as this is the size most frequently used for adults.

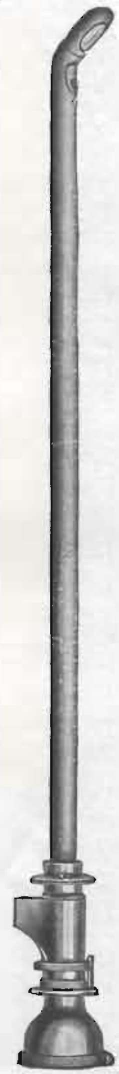
No. 1321*k*.	Similar Instrument, with upright image	£4 10 0
No. 1321*kz*.	Similar Instrument, with Zeiss-Kollmorgen optic ..	6 5 0
No. 1321*z*.	Similar Instrument, with Zeiss optic	6 10 0
No. 1323.	**Dr. Rumpel's Cystoscope,** Fig. 1323, with optical part so arranged that the angle of vision becomes larger, and is shifted slightly towards the orificium. Diam. No. 21	4 12 0
No. 1325.	**Nitze's Cystoscope,** with two channels for irrigation, Fig. 1325. Through one of the channels the water enters; through the second the contents of the bladder find an outlet. With upright image	6 3 0
No. 1325*kz*.	Similar Instrument, with Zeiss-Kollmorgen optic ..	7 18 0

No. 1321.

No. 1323.



No. 1325.



No. 1327.

No. 1327*a*.

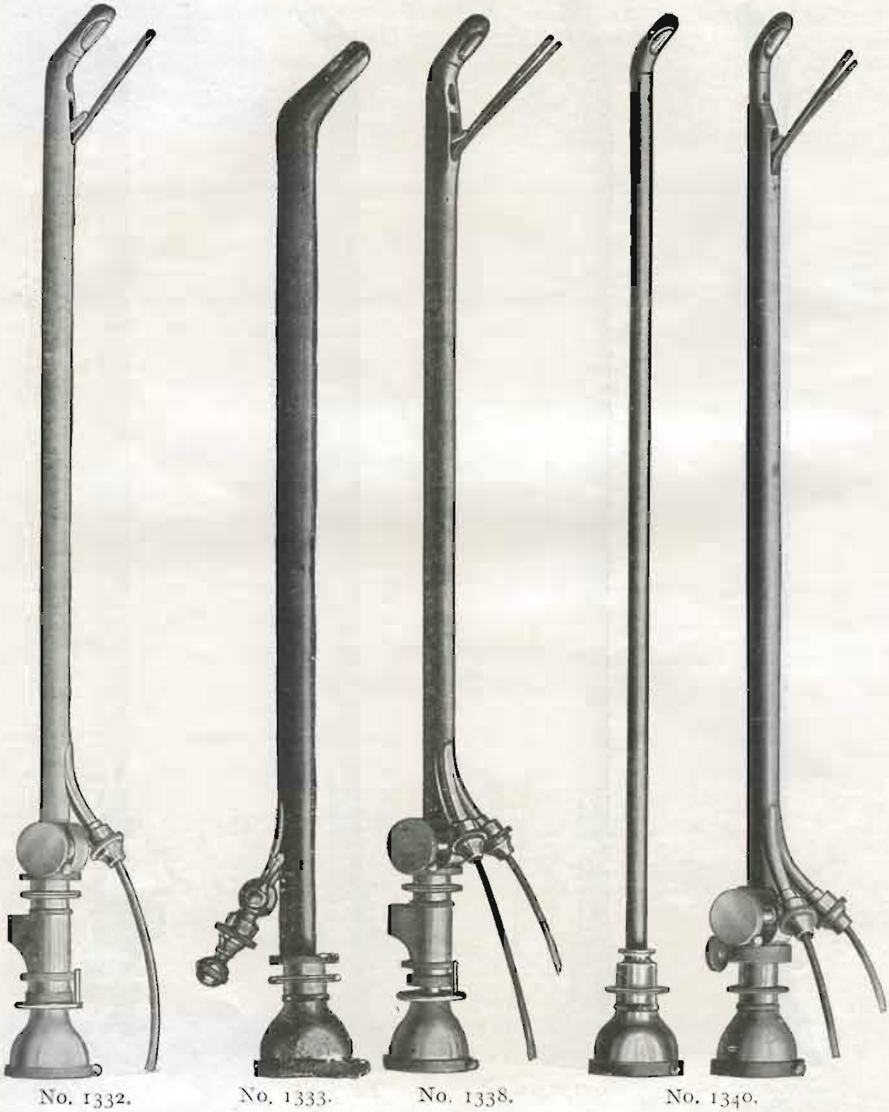
No. 1327. Cystoscope, for irrigation, by Schlagintweit, Fig. 1327 **£5 15 0**

In this instrument the telescope can be removed and a tube with a two-way tap introduced instead to empty and fill the bladder. The larger diameter thus available for irrigation is an advantage. Diam. No. 21.

No. 1327. Similar Instrument, with upright image **£6 3 0**

No. 1327*kz*. Similar Instrument, with Zeiss-Kollmorgen optic .. **7 18 0**

No. 1327*r*. Similar Instrument, with Dr. Rumpel's optic (see No. 1323) **6 10 0**



No. 1332. No. 1333. No. 1338. No. 1340.

No. 1332. Cystoscope, with arrangement to introduce *one* catheter, which can be raised or lowered with Albarran's lever. Diameter No. 23 Charrière. The instrument is provided with irrigation (as described under No. 1327)	£7 10 0
No. 1332*k*. Similar Instrument, with upright image	7 18 0
No. 1332*kz*. Similar Instrument, with Zeiss-Kollmorgen optic ..	9 15 0
No. 1332*z*. Similar Instrument, with Zeiss optic	10 0 0

If the irrigation is not desired, the prices quoted for Nos. 1332 to 1332*z* will be reduced by 8/–.

No. 1333. Cystoscope, for introducing a catheter in the female bladder, Fig. 1333	5 5 0

No. 1338. Cystoscope, with arrangement to introduce *two* catheters, with Albarran's lever to raise or lower them. Diameter of the instrument No. 23 Charrière. Fig. 1338. The instruments are provided with irrigation (as described under No. 1327) .. **£8 10 0**

No. 1338*k*. Similar Instrument, with upright image **8 18 0**

No. 1338*kz*. Similar Instrument, with Zeiss-Kollmorgen optic .. **10 12 0**

No. 1338*z*. Similar Instrument, with Zeiss optic **10 18 0**

If the irrigation is not desired, the prices quoted for Nos. 1338 to 1338*z* will be reduced by 8/–.

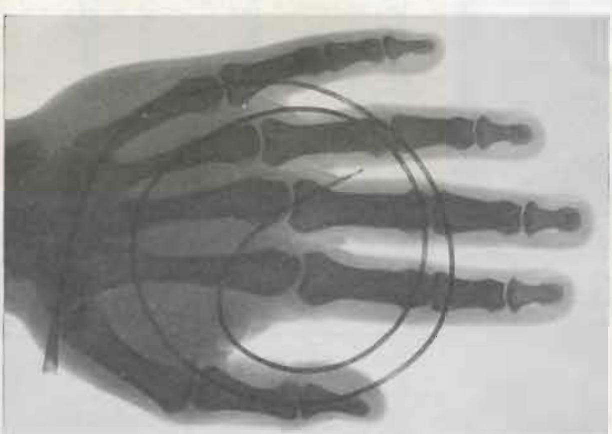
No. 1340. Dr. Bierhoff's Cystoscope, for the introduction of two catheters, with irrigation, Fig. 1340 .. .. **8 9 0**

This instrument is very convenient if one or both catheters are *to be left in position after the cystoscope has been withdrawn,* to collect urine from the right and left kidney separately. A STRAIGHT lamp is screwed on to the cystoscope No. 1321, diameter No. 16 Charrière. The cystoscope can then be withdrawn *alone,* without having to make first half a turn with the tube through which the catheters have been introduced ; this tube can be withdrawn afterwards without twisting or interfering with the catheters.

The price includes the taps for irrigation and 2 catheters No. 6. If desired, the instrument can be supplied with a slightly larger diameter, so that catheters No. 7 may be used. The extra cost of this is **10**/–.

No. 1340*k*. Similar Instrument, with upright image **£8 17 0**

No. 1340*kz*. Similar Instrument, with Zeiss-Kollmorgen optic .. **10 12 0**



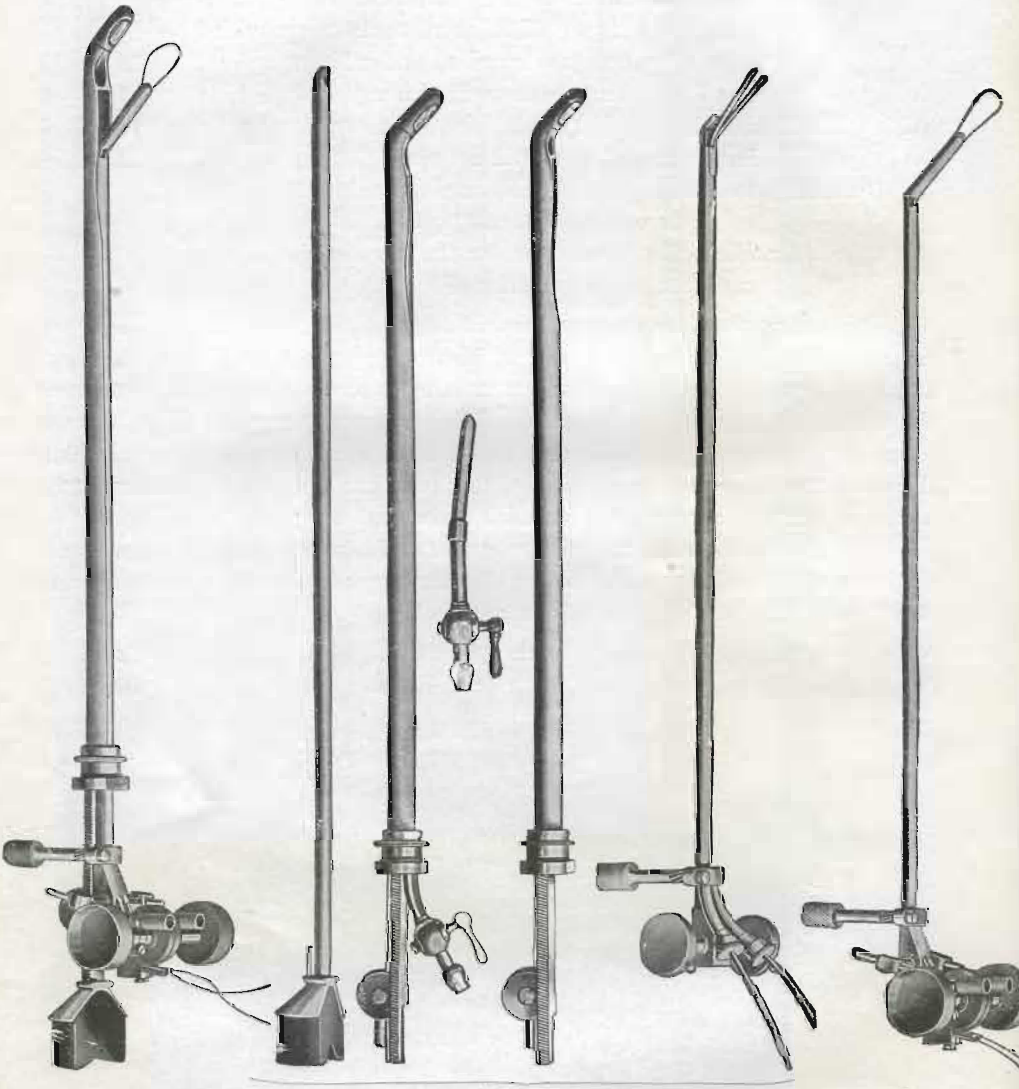
No. 1335.

CATHETERS FOR URETER CYSTOSCOPES.

No. 1334. Ureter Catheter, with cylindrical point, No. 5, 6, 7 or 8 Charrière **£0 5 0**

No. 1334*a*. Similar Catheter, with scale **0 5 6**

No. 1335.	Catheter opaque to X-rays ..	£0 5 6
No. 1335.	A Similar Catheter with ctm. scale .. .	0 6 6



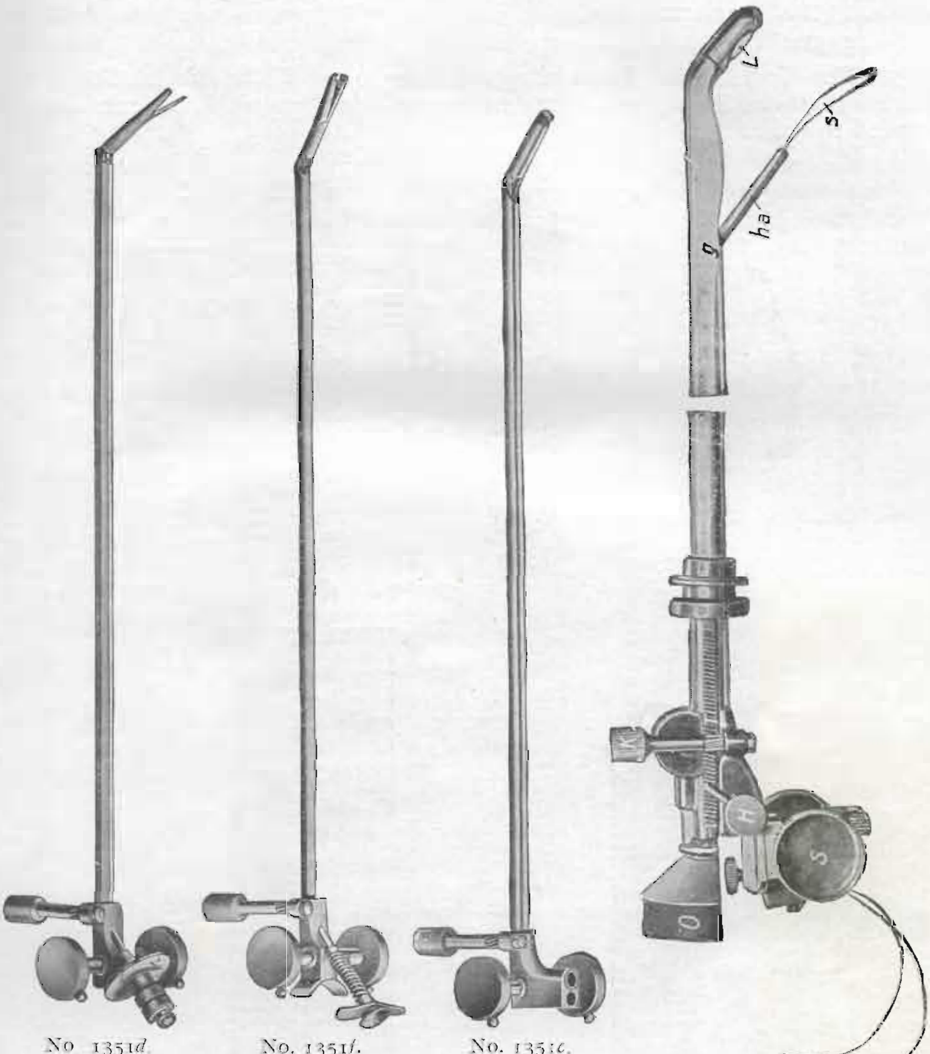
No. 1351. No. 1350. No. 1351*a*.

No. 1350. Kutner's Cystoscope, for examination and introducing catheters with Zeiss-Kollmorgen optic, Fig. 1350 .. .. £12 10 0

The price includes taps for the irrigation, two catheters No. 6, one catheter No. 7, cords, case, and one spare lamp.

No. 1351. Kutner's Cystoscope, for operating in the bladder, Fig. 1351 .. .. £9 0 0

With this instrument, catheters, snare, forceps, dilators for the ureters, a knife for making incisions in the opening of the ureters, a cautery burner, etc., can be used.



No. 1351*d*. No. 1351*f*. No. 1351*c*.

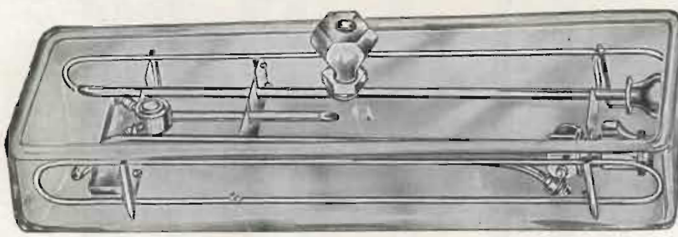
The great advantage compared with other operating cystoscopes, is that the operating instruments can be *moved forward or backward* by rack and pinion, *without altering the position of the optical and illuminating parts*, and without thereby irritating the patient unduly.

The snare can be raised or lowered in a similar way as the Albarran levers are raised. If the removal of a polypus, etc., causes some hæmorrhage, the bladder can be washed out without removing the instrument. The diameter is 23 Charrière.

No. 1351*a*.	Carrier for the cautery snare for cystoscope No. 1351	£6 10 0
No. 1351*c*.	Carrier for the cautery burner	3 6 0
No. 1351*d*.	Carrier for the dilatator or knife	3 6 0
No. 1351*f*.	Carrier for the forceps	3 6 0
No. 1351*w*.	Connecting cords	0 16 0
No. 1351*z*.	Case	0 16 0

The *Blum*, *Casper*, *Freudenberg*, *Gagstatter*, *Lang*, *Kader*, *Ringleb*, *Schlagintweit*, *Wossidlo*, *Young*, etc., Cystoscopes, not described in this list can be supplied to order.

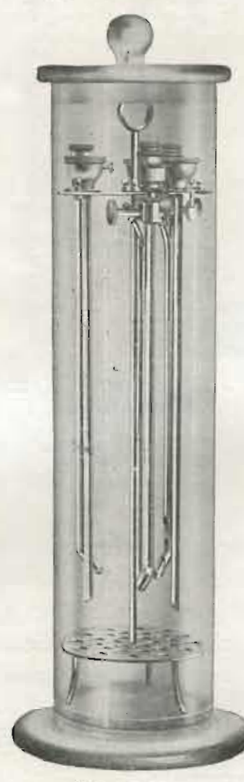
Cameras to be attached to cystoscopes, and cystoscopes with arrangement to obtain photographs of the interior of the bladder can be supplied. Illustrations and prices of these instruments can be had on application.



No. 1371.

No. 1371. Glass Vessel, with metal frame, for sterilising cystoscopes, Fig. 1371 .. .. £0 16 0

No. 1372.



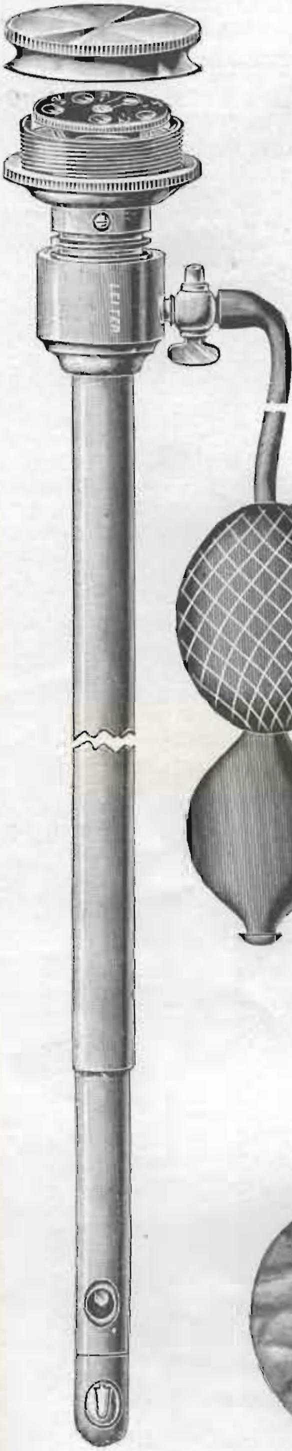
No. 1373.

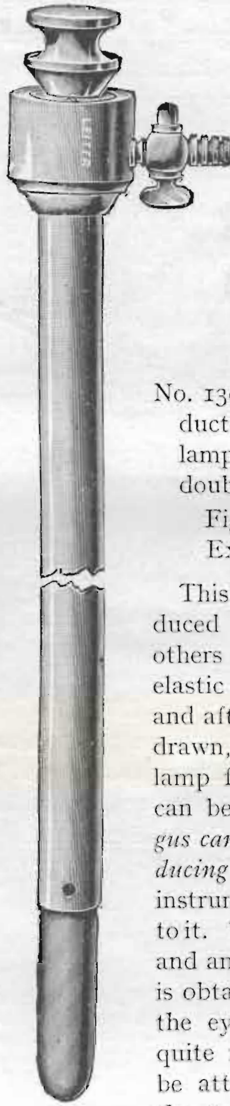
No. 1372.	Glass Vessel, for sterilising one cystoscope in hydrargyrum oxycyanatum, Fig. 1372	£0 7 0
No. 1373.	Similar Vessel, with metal frame, suitable for sterilising four cystoscopes, Fig. 1373	1 1 0

No. 1378.

No. 1378.	For practising with cystoscopes, and for demonstrations, a Phantom, as shown in Fig. 1378, exhibiting artificial tumours, stones, and foreign bodies, etc., is very convenient	£0 18 0
No. 1379.	Dr. Nitze's Phantom, Fig. 1379 . .	£2 8 0

No. 1379.





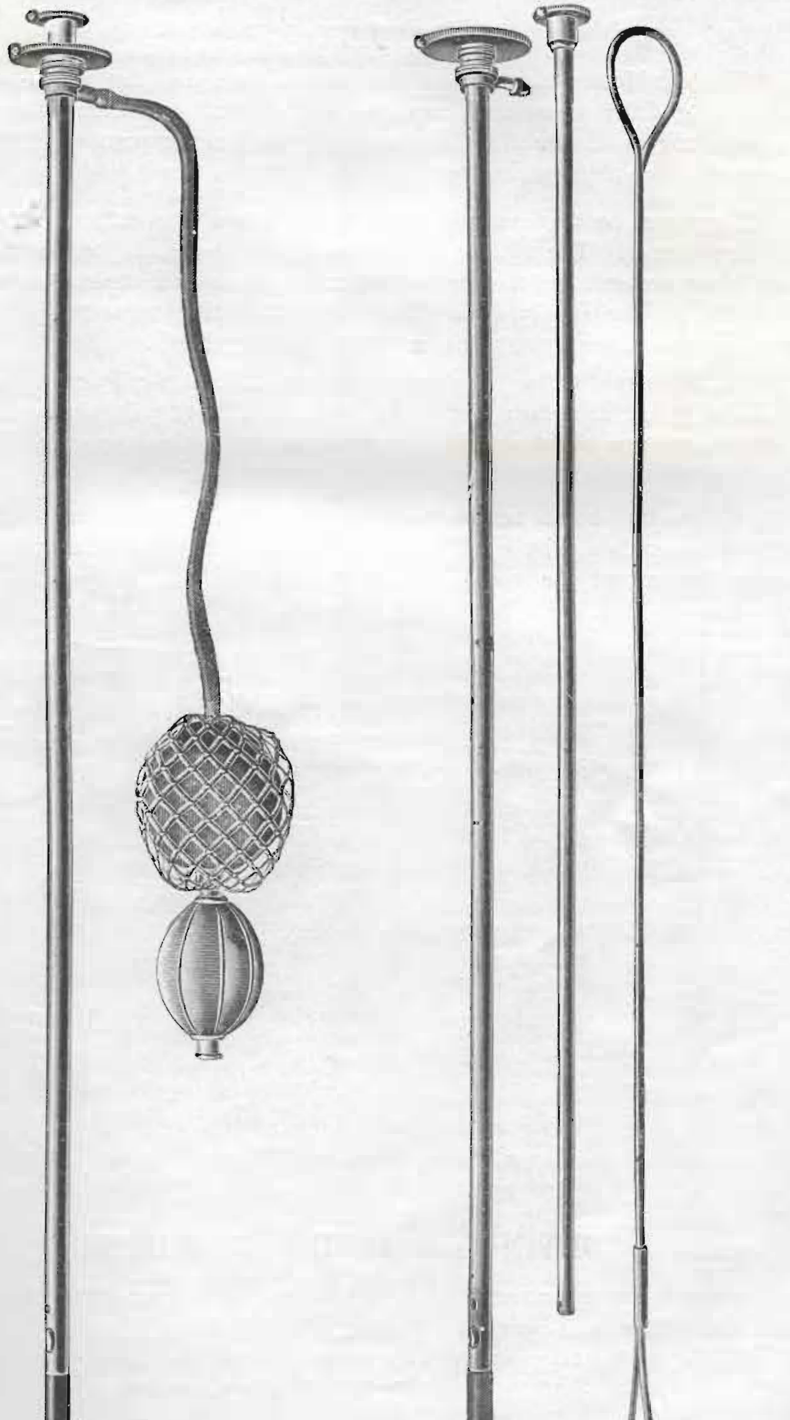
No. 1390. Gastroscope, with conductor tube, cords, 2 spare lamps with metal filament, double bellows, and case,

Fig. 1390 ..	£14	0	0
Extra spare lamps	0	5	9

This instrument can be introduced directly in some cases, in others the conducting tube with elastic conductor has to be used, and after the latter has been withdrawn, the optical part with the lamp for examining the stomach can be introduced. *The œsophagus can be seen clearly while introducing the conducting tube,* if the instrument No. 1240 is attached to it. The stomach can be inflated and an excellent view of the walls is obtained (see illustrations). If the eye of the observer is not quite normal, a recoss disc can be attached, which will increase the price of the instrument by **£1 10s.**

No. 1390.   No. 1340.

No. 1394. **Dr. Elsner's Gastroscope,** with connecting cords, double bellows, and elastic conductor of metal **£14 0 0**



No. 1394.

ELECTRIC MOTORS.

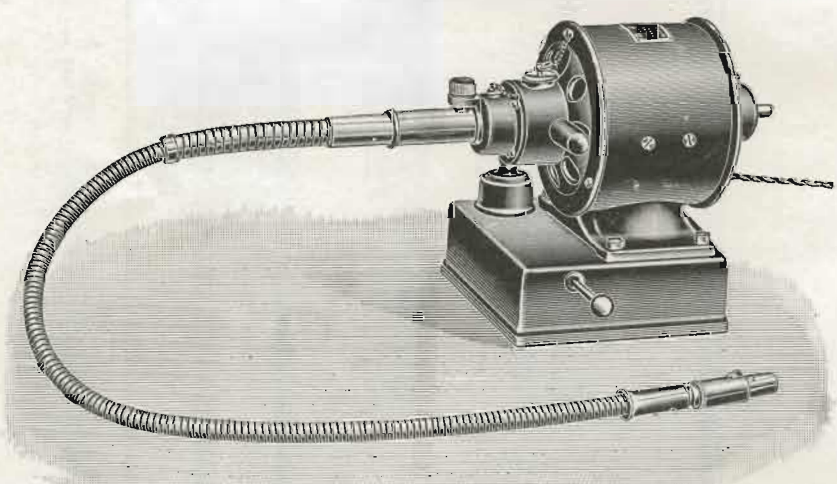
(*See also pages* 45–51.)

Electric Motors have come into general use, and are very convenient for driving drills, saws, and trephines for surgical operations, for applying massage and rapid vibration treatment, for working air-pumps for pneumatic massage, for centrifuges, etc., etc.

They can be worked from batteries or from the current supplied for lighting houses. The winding of the motors has to be adapted to the special conditions present, and in ordering a motor, please state the number of volts, and whether the supply is continuous or alternating current ; in the latter case it is also necessary to mention the number of periods.

If the current from the mains is not available, a 6-cell accumulator or a bichromate battery with large cells will work a 12-volt motor very well. Our motors are shunt wound ; in consequence of this the speed is almost independent of the amount of work they have to perform.

A rheostat should be used with every motor. The current ought to be turned on gradually by diminishing the resistance. The same rheostat also serves to control the speed of the motors.



No. 1411.

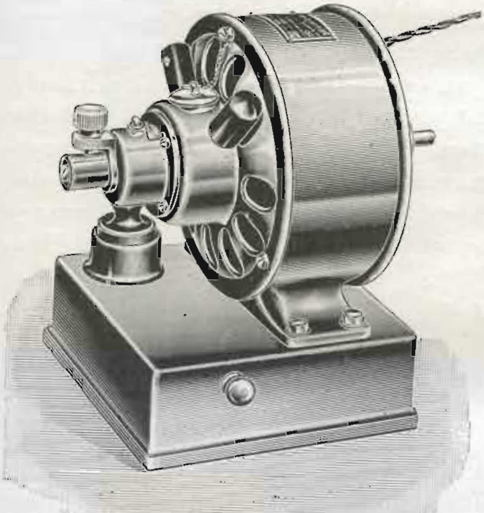
CONTINUOUS CURRENT MOTORS.

For surgical operations, for massage, etc., with connecting plug, switch, and rheostat, on cast-iron base, Fig. 1411.

The Motor Transformers Nos. 2000–2005, and the Sinusoidal Motors Nos. 1900 and 1901 can also be used for surgical operations and for massage.

		12	100	200-250 volts.
No. 1411.	1-8th horse-power ..	£7 0 0	£7 15 0	£8 14 0

The motors are powerful enough for all surgical operations in the nose and ear, on the skull, and for all purposes of massage.



No. 1420.

No. 1420. **Alternating Current Motor** for surgical operations and for massage, with connecting plug, switch, and rheostat, on cast-iron base,

Fig. 1420—

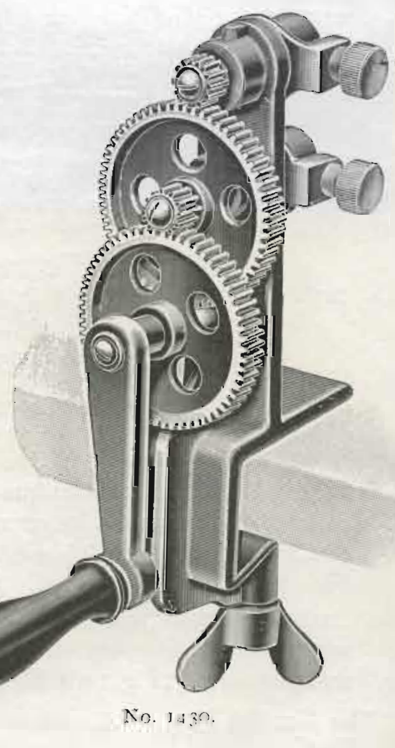
(*a*) For 100 volts, **£10 10 0**

(*b*) For 200 volts, **£10 16 0**

In ordering this motor it is necessary to mention the number of volts *as well as the number of periods* of the supply ; a motor which is arranged for fifty periods will not run with eighty periods, and *vice versa.*

The Motor No. 1420 *is provided with a collector and brushes*, and the speed can be varied in wide limits by means of the rheostat. The so-called induction motors have no collector, and are therefore much cheaper in price, but the speed of these induction motors is not under control, they have to run synchronously with the dynamo. For this reason they are, in our opinion, unsuitable for surgical work, but they can be used for various other purposes.

No. 1430. **Strong Transmission Gear,** Fig. 1430, to work any of the following drills, saws, massage appliances or air pumps by hand instead of electromotor **£1 15 0**



No. 1430.

FLEXIBLE SHAFTS AND HAND PIECES FOR THE SURGICAL MOTORS.

The flexible shafts connect the motor with the hand piece; they are made of thin steel wires twisted together to a cable, and this cable is enclosed in a flexible, nickel-plated metal tube. At one end of the flexible shaft there is a connecting piece fitting the motor; at the other end the hand piece is slipped on and held in position by a spring catch.

The hand pieces hold the drills, burrs, etc. They are released by drawing back a spring. The axles of our hand pieces run in ball bearings, and the covers can be taken off for sterilisation. The hand pieces are made in two sizes, either for small operations in nose or ear, or for the trephines for the skull; scme are provided with a ring or drigger to stop the drills instantaneously; other hand pieces convert the circular movement into a longitudinal one for operations with *straight* saws.

No. 1432. **Flexible Shaft,** diameter of the steel cable 5 millimetres, length 40 inches, for operations in nose and ear .. **£2 0 0**

No. 1433. **Flexible Shaft,** diameter of the steel cable 7 millimetres, suitable for trephines and for massage, length 40 inches **£2 10 0**

No. 1452.

No. 1456.

No. 1452. **Hand Piece,** for drills, with a shaft of 5 millimetres diameter. The cover can be taken off for sterilisation, Fig. 1452 .. .. .. **£1 12 0**

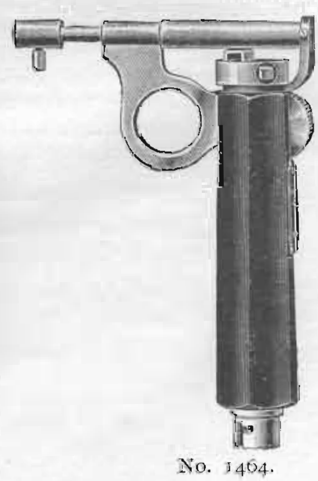
No. 1456. **Hand Piece,** with a drigger to stop the tools instantaneously, Fig. 1456.. .. **3 3 0**

No. 1462. **Handle** to convert the circular movement into a longitudinal one, for straight saws, chisels, etc., Fig. 1462 .. .. **£2 8 0**

No. 1464. **Similar Handle,** with arrangement to stop the tools instantaneously, Fig. 1464 **£3 0 0**

The Handles Nos. 1462 and 1464 fit the Flexible Shafts Nos. 1432 and 1433; the length of the stroke of the saws can be adjusted by turning a screw.

No. 1462.



No. 1464.

No. 1484.

No. 1496.

No. 1484. **Plain Stand** for surgical motors, Fig. 1484, with castors (the motor shown in illustration is not included in the price) **£1 14 0**

No. 1485. **Similar Stand,** with telescope arrangement to raise or lower the motor **3 8 0**

No. 1496. **Complete Outfit** for Hospitals, consisting of a motor of ⅛ of a H.P., with flexible shaft and hand piece, mounted on a stand in such a manner that it turns round its axis; foot switch, to start and stop the motor. The stand, made of polished oak, is provided with large castors, with india-rubber tyres, and with a drawer for the reception of shaft and hand piece, Fig. 1496 .. .. **22 0 0**

Without foot switch it will be **£5** less.

As supplied to St. Bartholomew's Hospital, Grantham Hospital, the Crown Agents for the Colonies, etc.

DRILLS, BURRS, TREPHINES, CIRCULAR SAWS, ETC.

No. 1500.

No. 1510.

No. 1500. **Drills for surgical operations,** of 1, 2, 3, 4, 6, 8, or 10 mm. diameter, Fig. 1500 .. .. .. each **3/0**

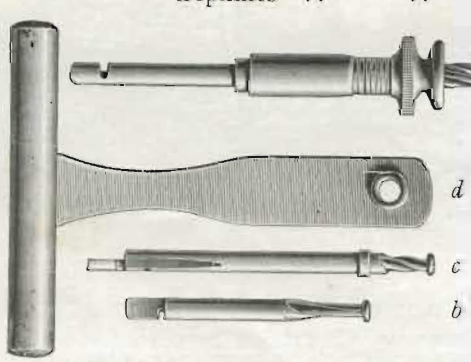
No. 1510. **Trephines,**

4	6	8	12 mm. diameter.
5/-	**6/-**	**7/-**	**10/-**each.

No. 1520.

No. 1520. **Round or conical Burrs,** of 3, 4, 6, 8, or 10 mm. diameter, Fig. 1520 .. .. **3/9** to **6/0**

No. 1530. Metal Stand, to hold a set of 8 drills, burrs, or trephines **5/0**



No. 1540.

No. 1540. **Drill for the skull,** with adjustable guard to control the depth of the hole, Fig. *a* .. **17/-**

Reamer with guard, to enlarge a circular hole sideways, Figs. *b* or *c* **3/9**

Handle, to guide the reamers, Fig. *d* **2/9**

No. 1548.

No. 1548. **Dr. Lassar's Multiple Needle.** Fig. 1548, for the treatment of red noses **16/-**

This multiple needle fits into one of the handles, No. 1462 or 1464.

No. 1551.

No. 1550.

No. 1550. **Straight Handle for circular saws,** Fig. 1550, with 1 circular saw and 2 keys to fix the blades .. **£0 18 6**

No. 1551. **Rectangular Handle for circular saws,** Fig. 1551, with 1 circular saw and 2 keys to fix the blades .. **1 2 0**

No. 1553. **Circular Saws,**

$\frac{3}{4}$ in.	1 in.	$1\frac{1}{4}$ in. diameter.
5/-	**5/6**	**6/-** each.

APPARATUS FOR MASSAGE AND MECHANICAL VIBRATION.

Massage is undoubtedly of great benefit in many diseases due to defective circulation or metabolism. There is also a desire on the part of the public for treatment by physical methods, like massage, light, heat, etc.

With the help of the instruments described, mechanical massage and vibration may be applied either by doctors or the patients themselves.

MEDICAL MASSAGE.

Scientific Massage for therapeutic purposes has been developed during recent years, through the invention of practical machines, and the use of Medical Massage has thereby increased enormously. It is now used to a large extent, not only by masseurs, but by physicians and the public generally. Instead of being a treatment where manual skill is the essential feature, Medical Massage becomes more and more a treatment through machines, which can easily be employed by every medical man, without special training, and in many cases by the patients themselves, under medical advice, necessitating but simple directions.

This development of Medical Massage is but natural at a time when motors in all kinds of work successfully replace the work of human hands. With the aid of machines, massage can be done more quickly and more effectively, with a smaller expenditure of labour, and with greater regularity and uniformity, than by manual labour. The machines can be regulated to the exact force and speed required. The machines have thus helped to place this excellent remedy in the prominent therapeutic position where it rightly belongs.

With regard to the three different classes of massage—friction, tapping (tapotement), and vibration—it must be said that *vibratory massage* can only be given in a rational way through machines—the hand is not able to apply such rapid movements—thousands in a minute—as a vibratory machine does.

The same can likewise be said of the *tapping* (tapotement). Every one who has experienced the tapotement by a machine-driven, rapidly and regularly moved rubber hammer, will admit that such massage is quite impossible where the hand only is used.

With regard to *frictional* massage, the machine is a satisfactory substitute for the hand, especially where rapid movements are required.

The *physiological effects* of Medical Massage, and the benefits it confers, are nowadays recognized by the whole medical profession.

They are chiefly :—

On the Nervous System.—Pains are soothed, removed, or relieved, through the effect produced on the sensitive nerves. Partially or completely paralyzed nerves are stimulated, replenished, and in many cases completely restored.

The brain and spinal cord are influenced—chiefly through reflex action from the peripheral nerves—in different ways: viz.: depression is removed; the patient becomes animated and vivacious; tiredness disappears.

On the Circulation.—The circulation in the veins, arteries, and lymphatic vessels is increased, which creates better nutrition of the tissues, and prevents the accumulation of gouty, rheumatic, and similar products of disease, at the same time helping to dissolve and remove such abnormal products. On the blood itself massage has a very prominent effect through increased oxidation.

On the Muscles.—Massage effects contraction of the muscles; they become stronger, elastic, the massage creating better nutrition.

On the Lungs.—Better respiration, increasing the oxidation of the blood, and the elimination of the carbonic acid, loosening the phlegm and pleuritic adhesions.

On the Digestion.—Increases the digestive power and develops the muscles of the stomach, liver, bowels, etc. It has a direct influence on the nerves of the abdominal organs, and thereby creates better appetite, and better peristaltic movement.

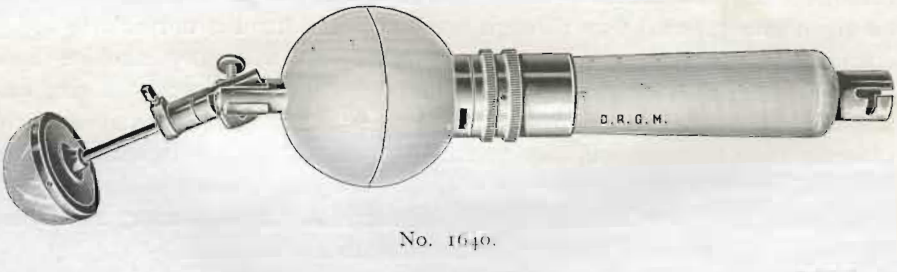
The *glandular secretion* (kidneys, liver, stomach, etc.), as well as the *function of the skin*, and the whole metabolism, is increased.

Gouty and rheumatic subacute and chronic *inflammation* is influenced in different ways through dissolution and removal of the inflammatory products.

Abnormal *accumulation of fat*—corpulence—is removed through the pressure, the metamorphosis, and the better assimilation of the fat.

INSTRUMENTS FOR APPLYING MASSAGE AND RAPID VIBRATION with the help of Electrical Motors.

The Motors Nos. 1411–1420, or the Pantostats Nos. 2005–2008, are required for working the Massage Vibrators, Nos. 1640–1650.



No. 1640.

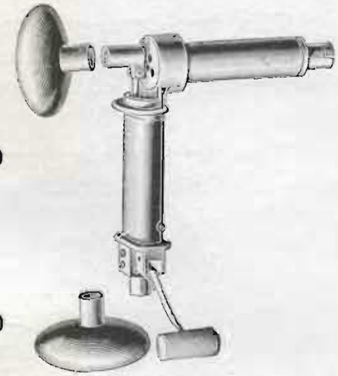
No. 1640. **Centrifugal Vibrator,** Fig. 1640 .. .. .. **£3 7 0**

The centrifugal power can be *varied and graduated* by altering the respective positions of a heavy weight and a light body, which revolve inside the cup, but the instrument need not be opened to make these alterations. The plates or sounds can be fixed to the instrument at any desired angle, or they can be removed altogether so that the instrument alone may be used.

No. 1646.

No. 1646. **Oscillator,** Fig. 1646, for general massage .. **£2 16 0**

No. 1650. **Dr. Johansen's Universal Vibrator,** Fig. 1650 **3 18 0**

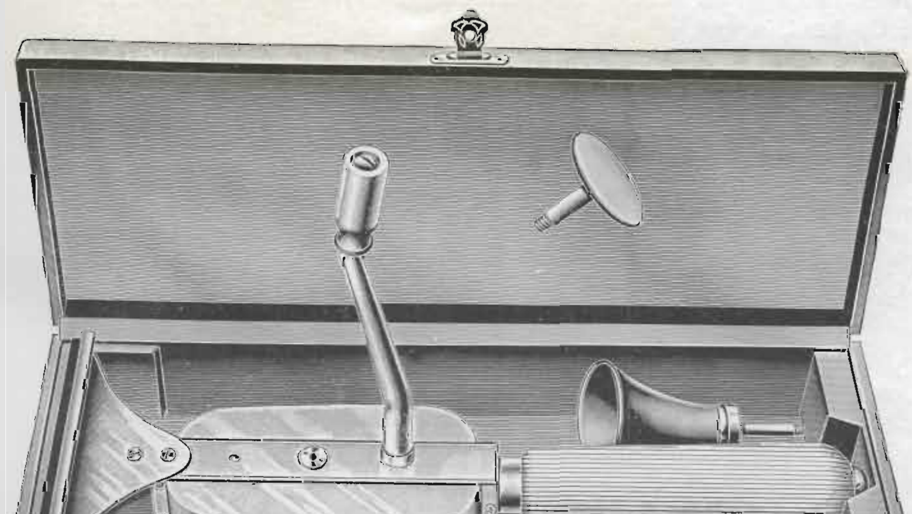


No. 1650.

The Johansen's vibrator is the most powerful, and should be used when the liver or other deep-lying parts have to be treated. Its power is, however, completely under control, and can be reduced to a pleasant, gentle vibration.

The discs make either a circular movement to produce vibration if attached on the left-hand side, or a striking movement if attached near the hammer ; the length of the stroke can be varied in wide limits.

No. 1652.	Round vibrating disc, diameter 3 centimetres ..	**£0**	**4**	**0**
No. 1653.	.. .. ,, $4\frac{1}{2}$,, ..	**0**	**4**	**6**
No. 1654,	,, ,, ,, 6	**0**	**5**	**0**
No. 1656.	Hammer, lined with indiarubber . ..	**0**	**6**	**0**

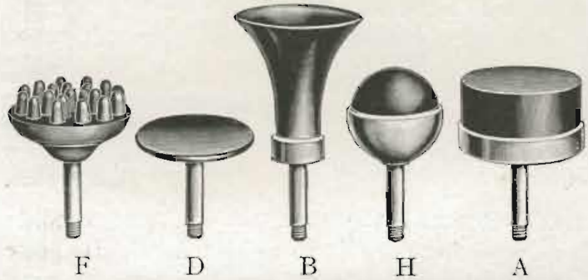


No. 1657.

No. 1657. Dr. Johansen's Vibrator, Fig. 1657 .. .. **£1 12 6**

This *hand-driven* vibrator is suitable for applying tapping and friction massage; it can be regulated to any strength, and runs smoothly, without shaking the hands of the operator. The construction and workmanship are perfect.

The discs shown in illustration can be attached, for the massage of tender parts like the head, larynx, etc. The prices of F to H are **2**s. **6**d. each, A is **3**s.



No. 1658. Dr. Johansen's Electric Vibrator, for rapid vibrations and tapotement, Fig. 1658 .. .. **£5 5 0**

This apparatus can be supplied for either 12, 100, or 200 to 250 volt continuous current, or else for alternating current. The voltage and kind of current for which it is required have to be stated when ordering the apparatus.

Owing to an ingenious but simple construction, this motor is the most perfect of the numerous types of hand motors existing. The intensity of the stroke can be varied in the widest limits, from a very gentle vibration suitable for the head, larynx, etc., up to a powerful stroke sufficient for the abdomen.

No. 1659. Dr. Johansen's Motor for Massage, especially for massage of the digestive organs, Fig. 1659 .. **£6 0 0**

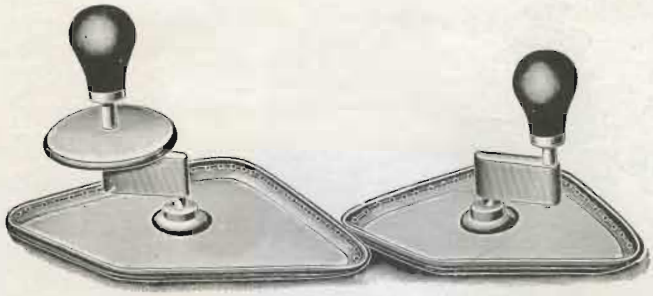
The price includes two discs of different sizes.

The motor can be supplied for either 12, 100, or 200 to 250 volt continuous current, or else for alternating current. The voltage and kind of current for which it is required have to be stated when ordering the apparatus.

The Centrifugal Vibrator, No. 1640, is to be recommended if a pantostat or surgical motor is available.

No. 1658.

No. 1659.



No. 1677.

No. 1677. Dr. Johansen's Apparatus for Abdominal Massage, *Fig.* 1677 .. .. £0 16 0

The price includes one weight.

Price of extra weight 0 2 0

This apparatus is used chiefly for treating constipation, flatulence, atonic and anæmic conditions. *It can be used by the patients themselves*: the handle has to be turned round with one or both hands, and the power of the stroke can be varied by altering the eccentricity of the crank, or by adding one or two weights below the handle.

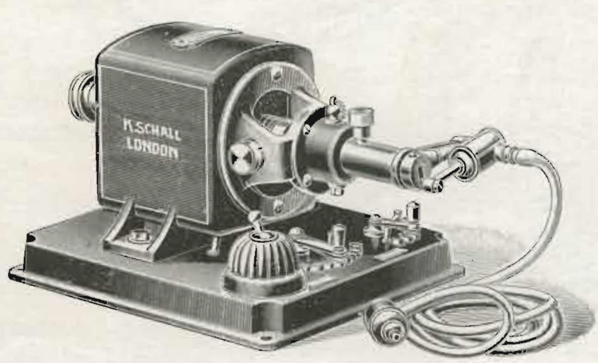
AIR PUMPS FOR PNEUMATIC MASSAGE OF THE EAR, ETC.

The Air Pumps can be attached either to our Pantostat No. 2005, or to one of the Motors Nos. 1410–1420, 2000.

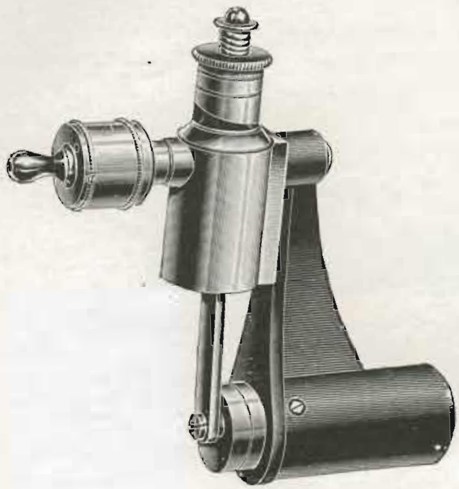
The Air Pump No. 1672 can also be used for massage of the eye or face, for supplying a current of air for the Eustachian tube, or for sucking out pus, saliva, etc. The length of the stroke of the piston (*i.e.*, the quantity of air which is being compressed) can be varied while the pump is working.

No. 1670. **Air Pump,** for pneumatic massage of the ear, as shown in Fig. 1670. £2 2 0

The price includes a suitable rubber tube, an ear funnel with glass window. The motor shown in the illustration is not included in the price.



No. 1670.



No. 1672.

No. 1672. **Air Pump,** with three taps, for pneumatic massage of the ear or the Eustachian tube, for hot-air syringes, or for removing pus, etc., Fig. 1672 . . **£2 15 0**

No. 1677.

No. 1677. **Air Pump,** with two cylinders, for suction and for compression, Fig. 1677 .. .. .. **£5 0 0**

(The motor and the spray bottle, etc., shown in illustration, are *not* included in this price.)

This air pump has been constructed for supplying compressed air for sprays, nebulizers, etc., for inhalations, for treatment with dry hot air, or compressed air, for producing Bier's hyperæmia by suction, etc.

The air pump has to be attached to our pantostats or surgical motors. A steady stream of compressed air is delivered by the upper nozzle, while at the lower nozzle the air is sucked in.

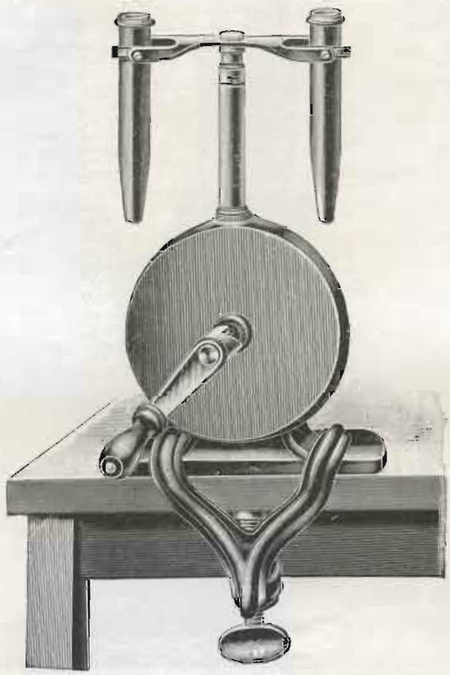
No. 1680.

No. 1680.	Large **Air Pump,** Fig. 1680, including two stout india-rubber tubes, three-way tap and connections ..	£7 0 0
	Cylinder for compressed air, 28 inches high, 14 inches diameter, with tap, manometer and safety valve, for use of throat, nose, and ear specialists ..	2 10 0
No. 1688.	Suction Cup, for penis and testicles	0 3 6
No. 1689.	Suction Cup, for the breast	0 4 6

No. 1690. Set of one Atomizer, one Nebulizer and one Powder Blower, to be used with the Air Pumps, Nos. 1677 or 1680, on nickel-plated stand, Fig. 1690 **12/6**

No. 1690.

CENTRIFUGES.



No. 1700.

No. 1700.	Centrifuge, for urine, blood, sputum, etc., to be driven by hand, for 2 test tubes, Fig. 1700 ..	£0 17 0
No. 1701.	Similar Centrifuge, for 4 test tubes	0 19 6
No. 1701.	Centrifuge, better quality, with silent running cog-wheel transmission, giving up to 3000 revolutions per minute, for 2 test tubes	1 6 0
No. 1704.	Similar Centrifuge, for 4 test tubes	1 10 0
No. 1704*e*.	Protecting Cover, enamelled	0 9 0
No. 1704*n*	,, ,, nickel-plated	0 15 0

Centrifuges for urine, blood, sputum, etc., driven by electric motors, giving a speed of about 3000 revolutions per minute. The apparatus are constructed so that when the motor is started, the tubes are not driven round at full speed at once; it takes a little time before they pick up full speed. When the motor is turned off, the tubes continue to revolve, diminishing the speed *gradually*, and come to rest without any jerk.

No. 1710.	Centrifuge, best quality, motor wound for 100 volt continuous current, for 2 test tubes	£4 5 0

No. 1711 (with protecting mantle).

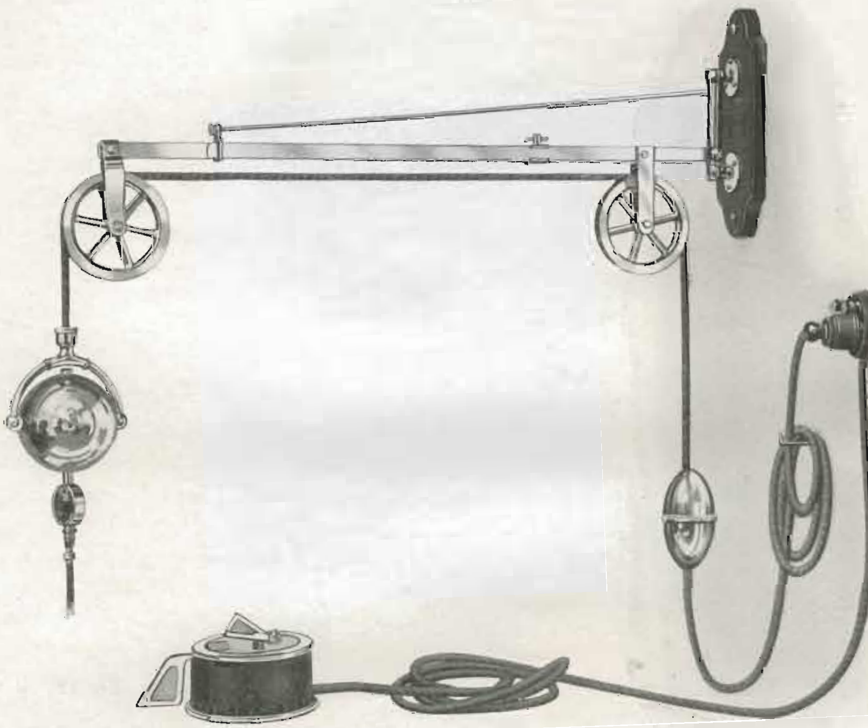
No. 1711.	Similar Centrifuge, for 4 test tubes, Fig. 1711 ..	£4	11	0

Similar centrifuges, with a smaller and cheaper quality motor, reducing the above prices by 25 per cent, can be supplied.

No. 1715.	Centrifuge, similar to No. 1710, but with hæmatokrit; the latter makes about 10,000 revolutions per minute	£5	10	0
No. 1716.	Similar Apparatus, but for 4 test tubes	6	10	0
	Protecting Mantle, for the Centrifuges Nos. 1710 to 1716, enamelled	0	9	0
	Protecting Mantle, nickel-plated	0	15	0
	If the motor has to be wound for 200 to 250 volts, the price will be increased	0	12	0
	If the motor has to be arranged for *alternating* current, the price will be increased	1	8	0

Extra test tubes **3**d. each. If provided with graduation, **7**d. each.

ELECTRIC MOTORS FOR DENTAL PURPOSES.



No 1720.

No. 1720. **Electric Dental Engine, complete** with bracket for suspension, foot contact, cable, and connecting dose, flexible shaft, Fig. 1720, for 65 to 125 volt *continuous* current	£16	10	0
No. 1720*b*. Similar Apparatus, but motor wound for 130 to 250 volt *continuous* current	17	10	0
No. 1721. Similar Apparatus, motor wound for 65 to 125 volt *alternating* current	18	0	0
No. 1721*b*. Similar Apparatus, motor wound for 150 to 250 volt *alternating* current	19	0	0

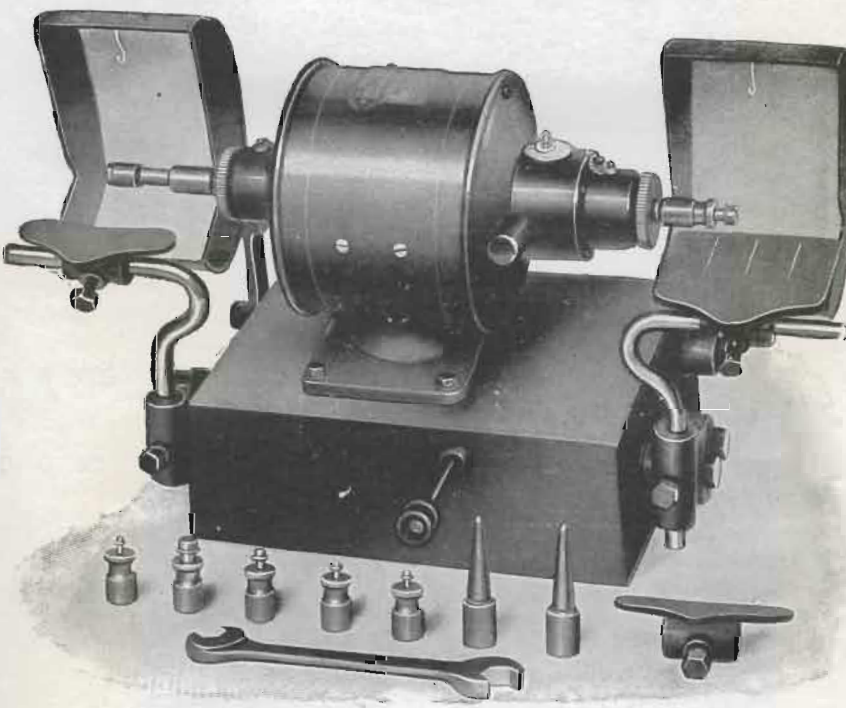
In ordering motors for alternating current, please state voltage and *periodicity* of the supply.

No. 1722. Similar Apparatus, wound for 12 volts from accumulators, including one large 6-cell accumulator ..	21	0	0

Prices of separate parts :—

Motor, enclosed in a nickel-plated (or bronzed) sphere, suspended on a cable 4 yards long—

		£	s.	d.
No. 1724.	Wound for 65 to 125 volt *continuous* current ..	£7	10	0
No. 1724*b*.	Similar Motor, wound for 130 to 250 volts	8	10	0
No. 1724*c*.	Similar Motor, wound for 12 volts, from accumulators	6	15	0
No. 1724*d*.	Similar Motor, wound for 65 to 125 volt *alternating* current	8	10	0
No. 1724*e*.	Similar Motor, with transformer, to reduce 150 to 250 volt *alternating* currents to 100 volts	10	0	0
No. 1726.	Wall Bracket, nickel-plated or bronzed, with telescopic arm	2	12	0
No. 1727.	Foot Contact, with lever to start, stop, or reverse the motor, and with rheostat to control its speed, including flexible cable 4 yards long	4	15	0
No. 1729.	Connecting Dose, to connect the two cables ..	0	10	0

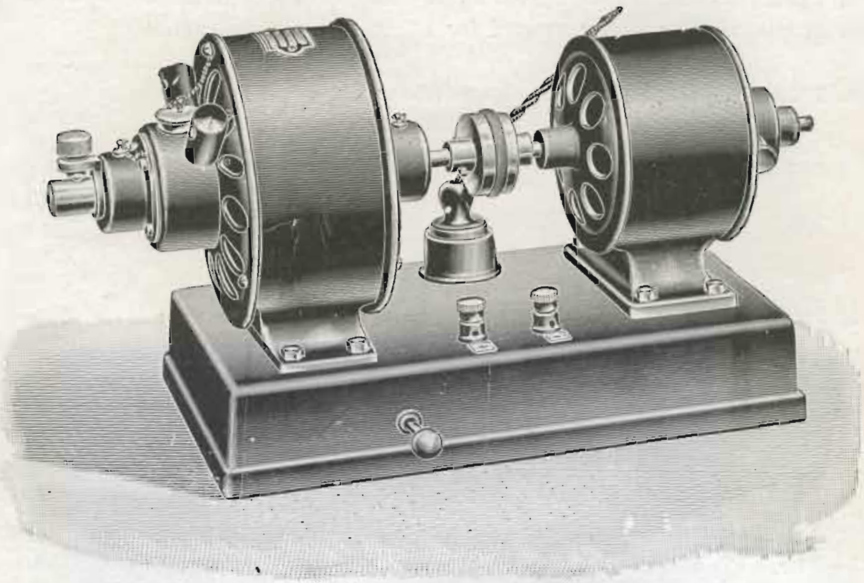


No. 1775.

		£	s.	d.
No. 1775.	Electric Motor, for grinding, polishing, circular saws, etc., Fig. 1775, including two hand-rests and eight chucks, for 65 to 125 volt *continuous* current ..	£8	0	0
No. 1775*b*.	Similar Motor, wound for 130 to 250 volt *continuous* current	9	0	0
No. 1775*c*.	Similar Motor, wound for 65 to 125 volt *alternating* current	9	15	0
No. 1775*d*.	Similar Motor, wound for 130 to 250 volt *alternating* current	10	10	0

MOTOR TRANSFORMERS.

(*See also page* 49.)



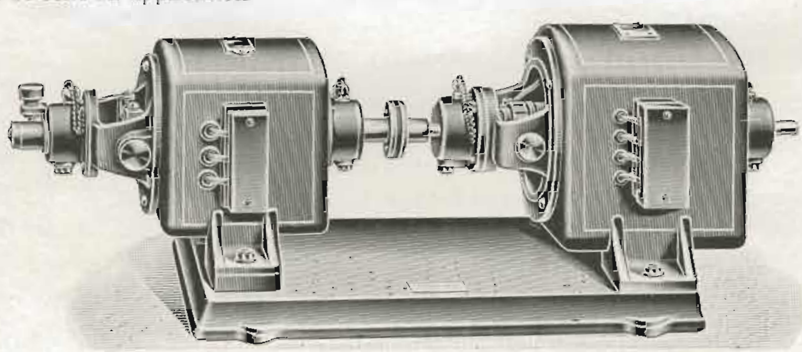
No. 1780.

No. 1780.	**Motor Transformer,** to convert an alternating current into a continuous current, for galvanisation and electrolysis, Fig. 1780. The continuous current dynamo supplies 70 volts and 1 ampère ..	**£20 0 0**
No. 1782.	**Similar Transformer,** for charging accumulators. The continuous current dynamo supplies 65 volts and 2·2 ampères	**24 0 0**

These prices *include the necessary rheostats.*

Larger motor transformers, suitable to give from 700 to 2,000 watts, for spark coils, arc lamps, etc., will be found under Nos. 2680–2687.

In ordering motor transformers of this kind, it is necessary to mention the *number of periods*, as well as the number of volts. If the number of periods is below 50 or above 70, the prices mentioned will have to be increased. Estimates will be sent on application.



No. 1790.

No. 1790. **Continuous Current Transformer,** for galvanisation, electrolysis, or surgical lamps, Fig. 1790. The dynamo supplies a continuous current of 65 watts (65 volts and 1 ampère) **£16 10 0**

This motor transformer is useful in cases where it is not safe to use the current from the main directly (for instance, in a hydro-electric bath, or in a hospital) on account of deficient insulation (see page 38). The dynamo is efficiently insulated from the motor.

No. 1793. **Similar Transformer,** suitable in addition for cautery burners requiring up to 18 ampères **£21 0 0**

As supplied to the War Office, University College Hospital, Cottage Hospital, St. Andrew's Infirmary, Aberdeen, etc., etc.

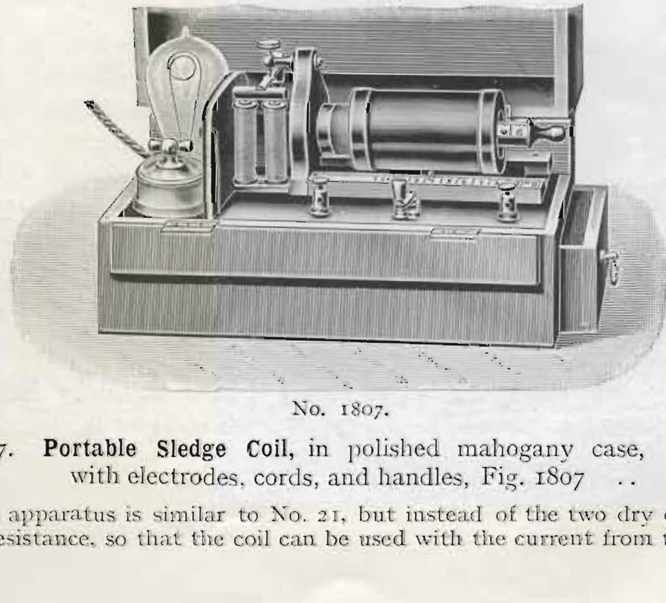
APPARATUS FOR USING THE CURRENT FROM THE MAIN.

The *first* Switchboard which was ever designed to use the current from dynamos for medical purposes was made by us in London in 1890. Since that time over 3000 switchboards of various types have been made in our workshops in London ; we have thus the *longest* and by *far the largest experience* in this kind of work.

The compliment has been paid us that all our switchboards have been copied by competitors, which proves that more practical constructions have not been found up to now.

SWITCHBOARDS for Galvanisation, Electrolysis, and Faradisation. (*See also pages 34–39.*)

FARADISATION.

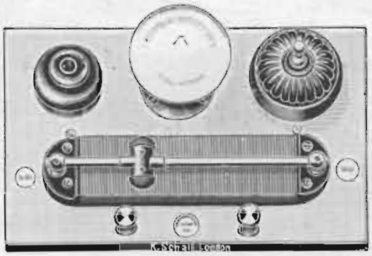


No. 1807.

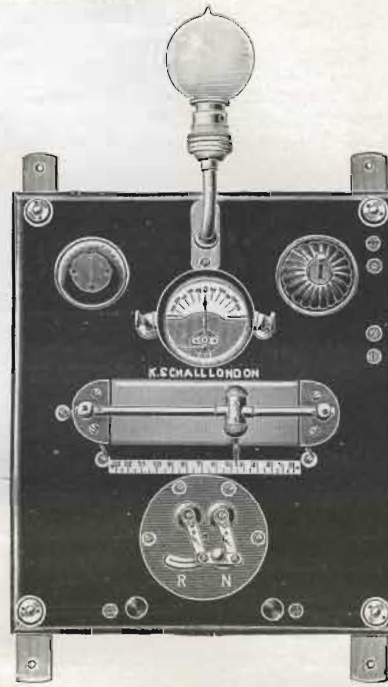
No. 1807. **Portable Sledge Coil,** in polished mahogany case, with electrodes, cords, and handles, Fig. 1807 .. **£4 12 0**

This apparatus is similar to No. 21, but instead of the two dry cells there is a lamp resistance, so that the coil can be used with the current from the main.

GALVANISATION, ELECTROLYSIS, AND FARADISATION.



No. 1820



No. 1822.

No. 1820. **Switchboard,** with volt selector, to vary the current from the main from 0·1 volt gradually up to about 70 volts, lamp, switch, and fuse, mounted on enamelled slate. Size, 6 in. by 10 in.; weight 4 lb. Fig. 1820 £2 16 0

No. 1822. **Similar Apparatus,** with a current reverser, galvanometer No. 281, cords, handles, and 4 electrodes in addition, Fig. 1822 .. .. £6 12 0

Size of slate, 11 in. by 12 in.

No. 1824.

No. 1824. Dr. E. R. Morton's **Portable Switchboard,** Fig. 1824, for galvanisation and electrolysis, in polished walnut case, with volt selector, milliampèremeter, handles, cords, and four electrodes £7 0 0

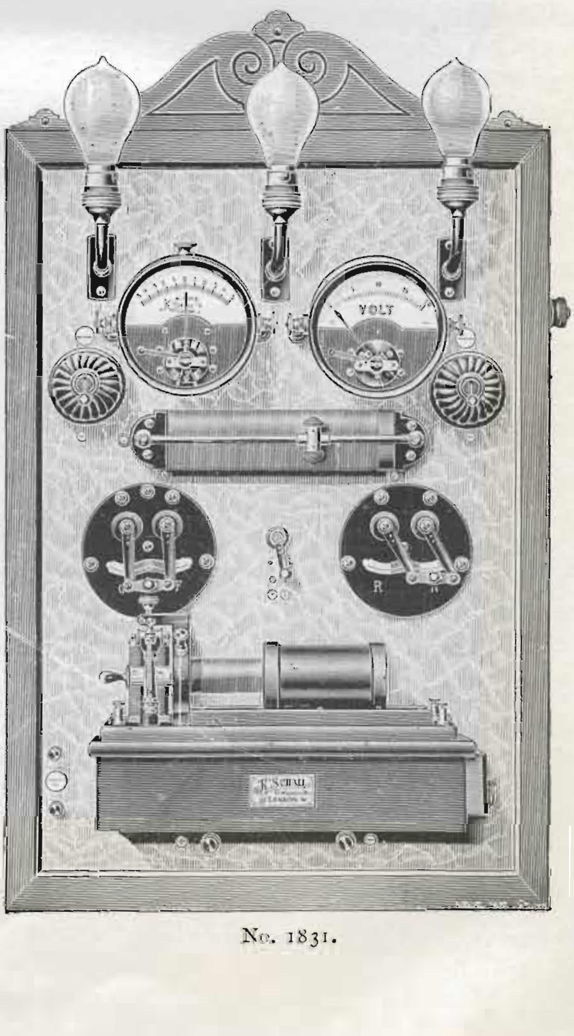
Size 8 in. by 13 in. by 9 in., weight 15 lb.

No. 1828.

No. 1828. **Switchboard,** with accessories as specified under No. 1830, but arranged in a portable polished walnut case. Fig. 1828 **£15 0 0**

Size, 15 in. by 22 in. by 12 in.

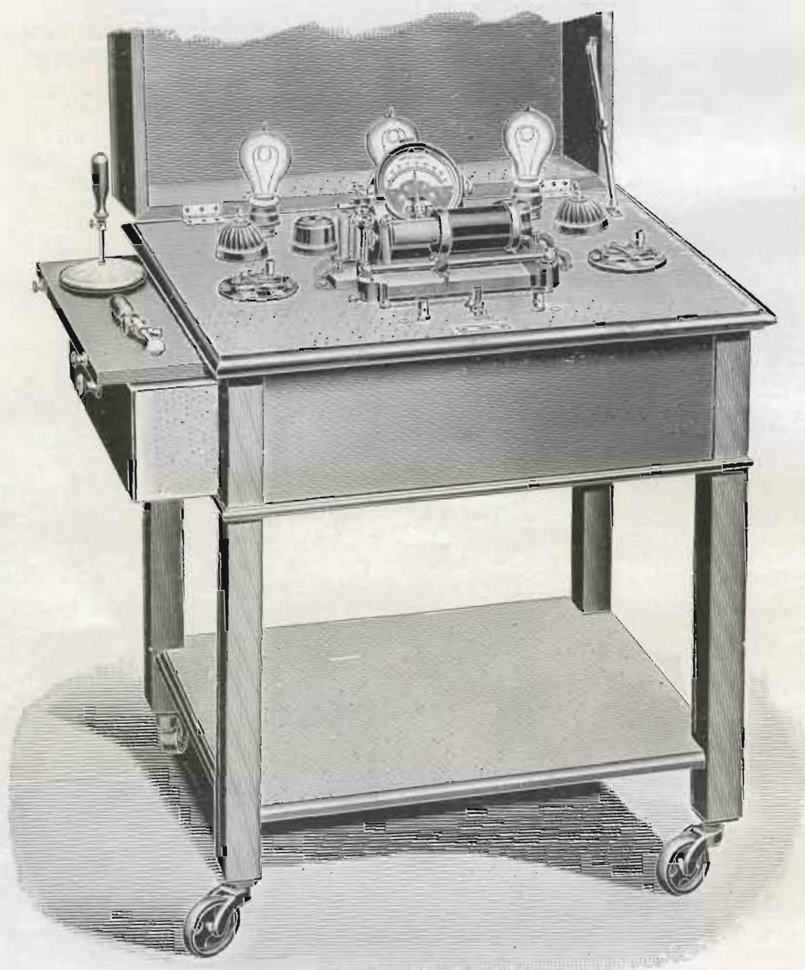
No. 1830. **Switchboard,** for galvanisation, electrolysis, and faradisation, consisting of volt selector to vary the current from the main from 0·1 volt gradually up to about 70 volts; sledge coil No. 27, galvanometer No. 288, with 2 shunts; current reverser and Dr. de Watteville's key, three lamps, switches, and fuses, mounted on enamelled slate or marble, cords, handles, and six electrodes. (The apparatus is similar to Fig. 1831, but is not provided with the voltmeter shown in the illustration) **£15 0 0**



No. 1831.

No. 1831. **Similar Apparatus,** with a voltmeter in addition, Fig. 1831 .. .. **£18 10 0**

The apparatus Nos. 1830 and 1831 can be enclosed in a polished mahogany case with glass door and lock, to protect it from dust and interference by servants. Price of the case, **£2 10s.**



No. 1837.

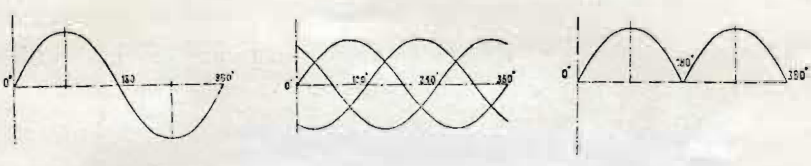
No. 1837. **Switchboard,** with accessories as specified under No. 1830, arranged on a trolley of oak, with castors covered with indiarubber, for hospital use, Fig. 1837 .. .. **£18 10 0**

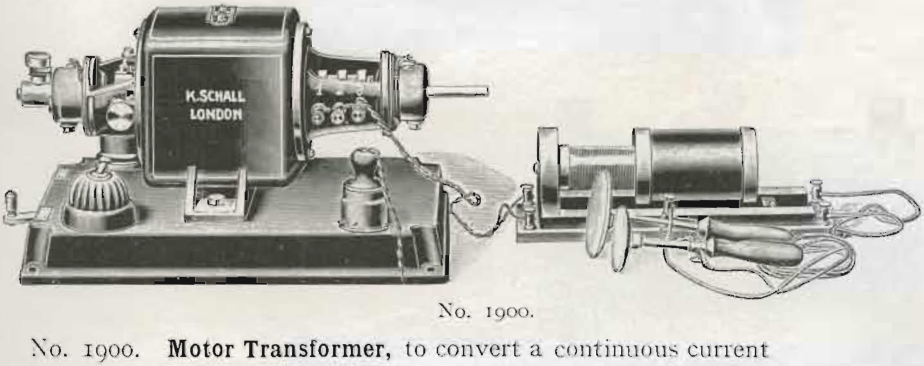
No. 1840. **Switchboard,** with accessories as specified under No. 1830, and with a voltmeter in addition, arranged in a desk-like mahogany case, with glass lid (suggested by the late Dr. M. Murray) £21 0 0

Estimates for other combinations of apparatus will be sent on application.

Apparatus Nos. 1830–1840 have been supplied to the War Office, the Crown Agents for the Colonies, St. Bartholomew's Hospital, Queen Alexandra Hospital, London Hospital, King's College, St. Mary's, Westminster, and St. George's Hospitals; London County Asylum, Claybury; National Hospital for the Paralysed; Hospital for Epilepsy and Paralysis; North Eastern Hospital for Children; Poplar Hospital, Seamen's Hospital, Greenwich; Victoria Hospital for Children, Hospital for Sick Children, Great Ormond Street, etc., in London. Royal Infirmaries in Edinburgh, Glasgow, Aberdeen, Halifax, Hull, Manchester and Liverpool; New General Hospital and Queen's Hospital in Birmingham; Victoria Hospital, Belfast; Lincoln County Hospital, Norfolk and Norwich Hospital, Essex and Colchester Hospital; St. Andrew's Hospital, Northampton; Sussex County Infirmary, Brighton; Infirmary, Lancaster; Infirmary, Norwich; Royal Alexandra Hospital, Rhyl; West Kent General Hospital, Maidstone; General Infirmary, Hertford; Stanley Hospital, Liverpool; Smedley's Hydropathic Establishment; Harrogate Hydropathic Company; Bath Club, Dover Street, London; and to over 300 Medical Men.

APPARATUS FOR TREATMENT WITH SINUSOIDAL CURRENTS.





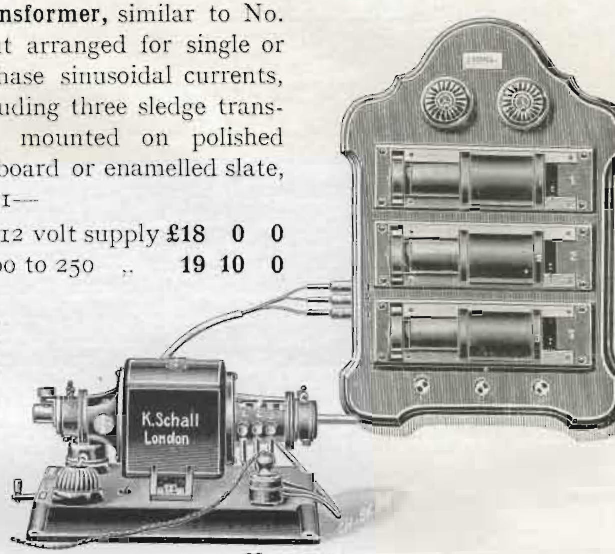
No. 1900.

No. 1900. **Motor Transformer,** to convert a continuous current into a single phase sinusoidal current, including rheostat to control the motor and the number of periods, and a sledge transformer to vary the E.M.F. of the sinusoidal currents gradually from a few volts up to nearly 100 volts, Fig. 1900—

(*a*) Motor wound for 12 volt supply	..	£12 5 0
(*b*) ,, ,, 200 to 250 volt supply	..	13 15 0

No. 1901. **Motor Transformer,** similar to No. 1900, but arranged for single or three phase sinusoidal currents, and including three sledge transformers, mounted on polished walnut board or enamelled slate, Fig. 1901—

(*a*) Motor wound for 12 volt supply **£18 0 0**
(*b*) ,, ,, 200 to 250 ,, **19 10 0**



No. 1901.

The Motor Transformers Nos. 1900 and 1901 can also be used for massage and rapid vibration treatment, and for surgical operations with drills, etc., or they can be provided with a Leduc's reverser (see No. 245), or a rhythmical interrupter, No. 248.

The Motor Transformers Nos. 2000 to 2008 for cautery, etc., can also be used for treatment with sinusoidal currents.

The secondary coils of the sledge transformers are provided with rack and pinion, though this is not shown in the illustration.

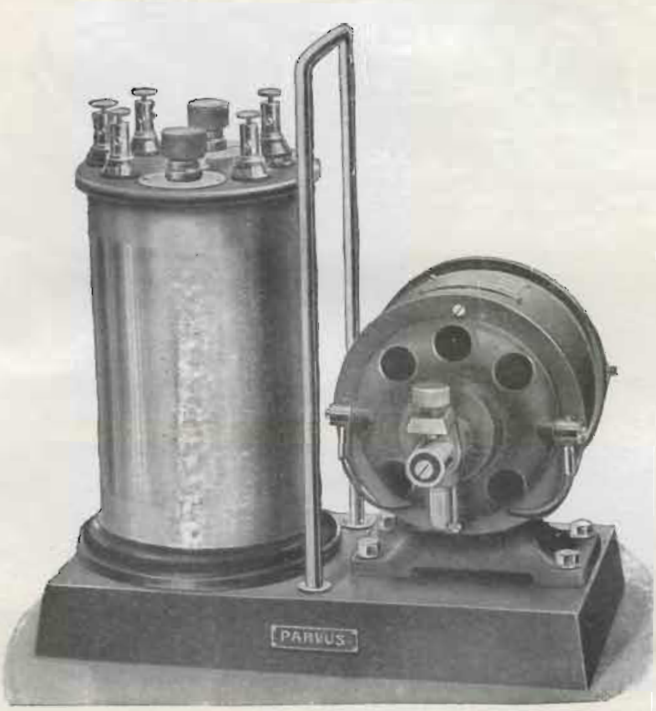
No. 1928.

No. 1928. **Transformer,** with volt regulator, to apply the alternating current from the main as sinusoidal current *in a bath*, Fig. 1928 .. **£4 4 0**

Before the alternating current from the main is applied in a bath, it should be transformed in order to protect the patient from shocks due to leakage (see pages 38 and 39).

APPARATUS FOR USING THE CONTINUOUS CURRENT FROM THE MAIN FOR CAUTERY, SURGICAL LAMPS, ETC., ETC.

(*See also page* 40.)



No. 1990.

No. 1990. **Motor Transformer "Parvus,"** to utilise the *continuous* current for cautery, surgical lamps, and Faradisation, Fig. 1990 .. .. .. **£12 16 0**

In ordering, please state the voltage of your supply.

Size—6½ inches wide, 12 inches long, 14 inches high. Weight—33 lbs.

This apparatus is amply large enough for all the cautery burners used for throat, nose, ear, and eye operations, and for all types of surgical lamps. The strength of current can be varied by means of sliding rheostats. The currents are transformed by a motor transformer, they are "earth free," so that neither patient nor operator can receive a shock. The voltage of the transformed current is reduced by means of an alternating current transformer. Motor and transformer are mounted on a cast-iron base.

X-RAY APPARAT

SCHALL'S MOTOR TRANSFORMERS.

No. 2000.

No. 2000.	**Motor Transformer,** Fig. 2000, $\frac{1}{16}$th of a H.P., suitable for cautery burners requiring up to 25 ampères, and for all sizes of surgical lamps. Wound for 200 to 250 volts	£15 10 0
No. 2002.	**Similar Transformer,** but larger size, $\frac{1}{4}$ H.P., suitable for cautery burners requiring up to 60 ampères, wound for 200 to 250 volts	23 0 0

In addition to cautery and light, Transformers Nos. 2000 to 2002 can be used equally well as motors for surgical operations with drills, for massage and rapid vibration, for air pumps, for sinusoidal currents, Leduc's Interrupter, Lewis Jones' "Rhythmical" Interrupter, etc.

[*Copies of unsolicited testimonials.*]

"IPSWICH, *March 21st* 1910.

"DEAR SIR,

"I have received authority from the Board of Management of the Suffolk and Ipswich Hospital to place an order for a Pantostat. Your competitors are most anxious to secure the order, but we have had one of your motor transformers No. 2000 in our operating theatre since about 1904; it has served us well, and we prefer to deal with you.

"Yours faithfully,

"P. E. RIPLEY."

December 23rd, 1910.

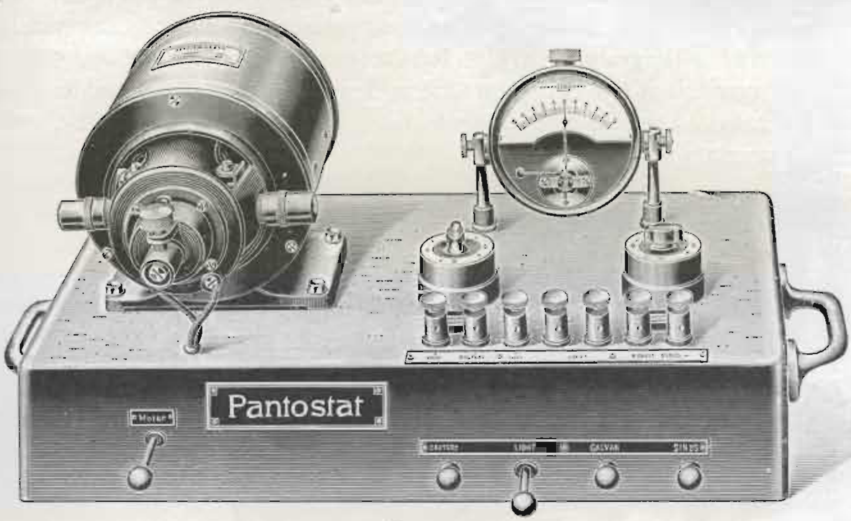
"I may say that the plant you supplied to my department in the Dundee Royal Infirmary (a Pantostat) gives me every satisfaction, and I am anxious to get the same material and quality for the Dundee Eye Institution.

"Yours faithfully, A. McGILLIVRAY, M.D."

PANTOSTAT.

A *Universal Apparatus* for using the current from the main for: *Cautery, Surgical Lamps, Galvanisation* and Electrolysis, Sinusoidal *Faradisation*; for Rhythmic Currents and for Leduc's Currents; for *Air Pumps, Massage,* and rapid *Vibration*; for Surgical *Operations* with drills, trephines, burrs, saws, etc.

All the currents are *transformed*; it is therefore impossible for patient or operator to receive a shock while using this apparatus, even if one pole of the dynamo is connected with earth.



No. 2005.

No. 2005.	**Pantostat** for *continuous* current of 200 to 250 volts, Fig. 2005	£24 0 0
No. 2008.	Similar apparatus, for *alternating* current, 100 volts	29 0 0
	Ditto, 200 to 250 volts	30 0 0
No. 2009.	**Pantostat,** with 6 accumulator cells of 50 amp. hour capacity, on trolly, Fig. 2009	35 0 0

Cords, handles, and 4 electrodes are included in these prices.

No. 2010.	Stand, made of enamelled steel tubes, and provided with castors covered with india-rubber tyres ..	3 0 0
A Metal Box for the reception of instruments, cords, etc., can be added to the Stand, price		0 12 0

(Copy of an unsolicited testimonial.)

154, Willis Street, Wellington, N.Z.,

September 5th, 1912.

"The Pantostat is giving perfect satisfaction, and is much admired.

"Yours faithfully,

"E. RAWSON."

Some references to Hospitals and Medical Men using our Pantostats will be found on pages 151 *and* 152.

These Pantostats were invented and brought out by us in London in 1903. They are the most useful electro-medical apparatus which have been constructed up to now, because they supply *all* the various currents and motive power which are required nowadays in medical and surgical practice, with the only exception of X rays. On account of their great convenience they are already being used by a large number of Hospitals and medical men (see references on pages 151 and 152.

These instruments have been copied by many other firms, but we have the *longest and by far the largest experience with these apparatus,* and this enables us to supply the *best quality obtainable. We guarantee our instruments for one year,* i.e., should any defect due to imperfect material or workmanship be discovered within a year, we undertake to make it good free of charge. Although over 600 of our Pantostats are in daily use, some of them since 1904, none has required serious repairs up to now, which is the best proof of good design, materials, and workmanship.

PANTOSTAT ON STAND. No. 2010.

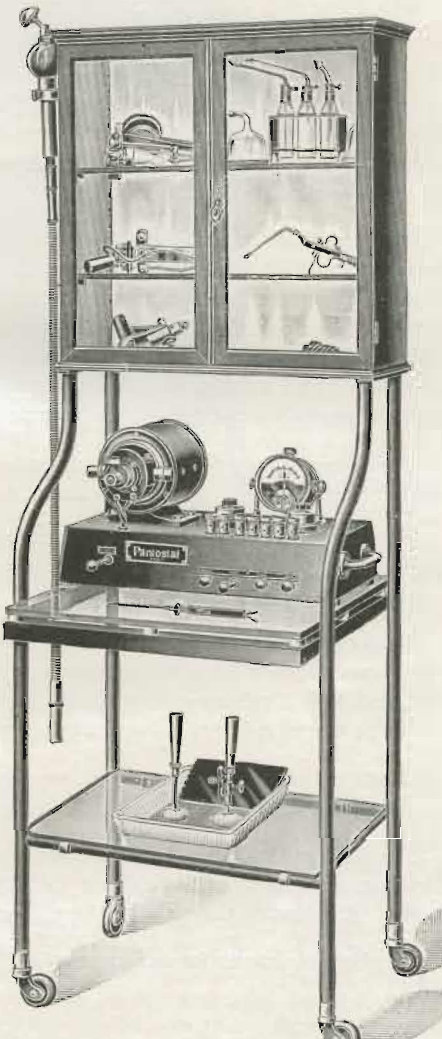
The motors consume less than one ampère on a 200 volt continuous current supply, and can be attached to any wall plug or lamp holder *without altering the size of the cables and fuses.*

The terminals are mounted on an ebonite plate, on which the words : Cautery, Light, Galvanisation, Faradisation, are engraved, so that no mistake can be made in connecting the cords.

The Apparatus No. 2005 consists of a motor of 1-eighth of a H.P. mounted on a base of cast iron, which contains five variable rheostats ; one of these controls the speed of the motor, the other four vary the strength of the circuits for cautery, surgical lamps, galvanisation, and sinusoidal faradisation.

The sliding contacts of these rheostats can be shifted either by the steel rods (as shown in Fig. 2005), which have to be drawn out to increase the strength of the current, or by cranks fitted with large ebonite knobs, which have to be turned round. We can supply either type ; as far as gradual increase or decrease of the current-strength is concerned, both are equally convenient, but the rods are preferable because the apparatus can be dusted and kept clean more easily, and moreover, the cranks may be left by mistake on "strong," whereas it is less likely that it will be forgotten to push the sliding rods home to "weak" after the application is over.

Stand for Pantostat, as shown in Fig. 2012, with glass shelves, and with cabinet for the reception of cautery instruments, surgical lamps, air pumps, etc., etc. Price of Stand No. 2012 .. **£9 12 0**



No. 2012.

(Copy of an unsolicited testimonial.)

JOHANNESBURG, *June 18th*, 1911.

"In conclusion, I must thank you for excellence of machine sent (a Pantostat), which works splendidly and is in every way a marvel of successful construction.

"Yours faithfully, A. M. MOLL, M.D."

For *cautery, surgical lamps, and sinusoidal faradisation,* the motor converts the continuous into an alternating current (see page 40), which is transformed by means of an alternating current transformer, so that at the secondary terminals of this transformer about 30 ampères and 10 volts are available for cautery, and 2 ampères and 20 volts for surgical lamps. Two sliding rheostats control these circuits, so that any size cautery burner or surgical lamp may be used.

To supply the current for *galvanisation, electrolysis and cataphoresis or ionic medication,* the motor is provided with a second winding, so that it acts also as a dynamo. The current which reaches the patient is therefore not connected at all with earth or with the current supplied by the main, and our pantostats can safely be used for applying currents even in a bath, without fear of exposing the patient to the dangers of a shock, which would be possible if the current from the main were used directly in a bath.

The terminals of the special wire for galvanisation are connected with a volt selector, which enables us to vary the voltage gradually from 0·1 up to about 70 volts ; the current passes through a reverser, and a dead beat milliampèremeter indicates the current reaching the patient. The M.A. meter is provided with two shunts, and indicates up to 5 M.A., every tenth part of a M.A. ; from 5 to 50 every single M.A. ; and from 50 to 500, ten by ten, M.A. A condenser is provided in this circuit to neutralize the pulsations of some dynamos.

For *sinusoidal faradisation* the transformed alternating current passes through a similar volt selector. Sinusoidal and continuous currents may be used combined.

For alternating circuits the Pantostat No. 2008 is provided in addition with an alternating motor, to drive a continuous dynamo, which supplies the various currents as described above.

If no current from the main is available, 6 *accumulator cells,* of about 50 ampère hours capacity may be used to drive a 12 volt motor, as shown in *Fig.* 2009 ; this is coupled to a dynamo giving about 100 volts and 2½ ampères, and this current is used for cautery, light, galvanisation, etc., as described above.

Drills, trephines, circular saws, or the various appliances for massage, etc., are connected with a flexible shaft which has to be attached to the motor.

Air pumps for pneumatic massage, or for compressing air ; Lewis Jones' Rhythmic Interrupter, No. 248, or *Leduc's Interrupter,* Nos. 245 or 246, etc., are attached directly to the axle of the motor.

Explicit directions for use are sent with the apparatus.

No. 2009

We have supplied our Pantostats amongst others to :—

The Admiralty ; the War Office ; the India Office ; the Crown Agents for the Colonies ; the Government of Egypt, India, and Ceylon ; the Cairo Sanitary Dept.

London Hospitals, etc.—Brompton Hospital, Central London Throat and Ear Hospital, Central London Ophthalmic Hospital, Charing Cross Hospital, German Hospital, Grosvenor Hospital for Women, Hospital of St. John and St. Elizabeth, London Homœopathic Hospital, Metropolitan Throat, Nose, and Ear Hospital, Middlesex Hospital, National Eye, Ear, etc., Hospital, New Hospital for Women, Orthopædic Hospital (Great Portland Street), Queen Alexandra Hospital, Queen's Hospital for Children, Samaritan Free Hospital, St. Bartholomew's Hospital, St. George's Hospital, St. James' Infirmary, Throat Hospital (Great Portland Street), Victoria Hospital for Children, Westminster Hospital, West London Hospital, Willesden Board of Guardians, Bath Club (Dover Street).

Provincial Hospitals, etc.—Batley Hospital ; Bedford County Hospital ; Birmingham and Midland Skin Hospital ; Croydon General Hospital ; Cumberland Infirmary, Carlisle ; East Suffolk and Ipswich Hospital ; General Hospital, Northampton ; General Hospital, Wolverhampton ; General Infirmary, Gloucester ; Kidderminster Infirmary ; Leigh Infirmary ; Manchester Children's Hospital ; Radcliffe Infirmary, Oxford ; Royal Bucks Hospital, Aylesbury ; Royal Sea

Bathing Hospital, Margate; Royal South Hants and Southampton Hospital; Royal United Hospital, Bath; Royal Infirmary, Hull; Royal Infirmary, Liverpool; Royal Baths, Harrogate; Salop Infirmary; South Devon and East Cornwall Hospital, Plymouth; Stanley Hospital, Liverpool; Victoria Hospital, Burnley; Victoria Hospital, Folkestone; Weston-super-Mare Hospital and Dispensary; York County Hospital; Cancer and Skin Institution, Glasgow; Dumfries and Galloway Royal Infirmary; Hospital for Diseases of the Ear, etc., Glasgow; Royal Infirmary, Dundee; Royal Infirmary, Edinburgh; Royal Infirmary, Glasgow; Cork Eye, Ear, and Throat Hospital; Sir Patrick Dun's Hospital, Dublin; Ophthalmic Hospital, Belfast; Royal Hamadryad Seamen's Hospital, Cardiff; Swansea General and Eye Hospital; Alfred Hospital, Melbourne; British Hospital, Colombo; British Hospital, Constantinople; Civil Hospital, Rangoon; General Hospital, Calcutta; New General Hospital, Rangoon; King George's Hospital, Lucknow; Royal Infirmary, Berwick; Warrington Infirmary; Tredegar Park Cottage Hospital; General Hospital, Mysore, India; Children's Hospital, Gloucester.

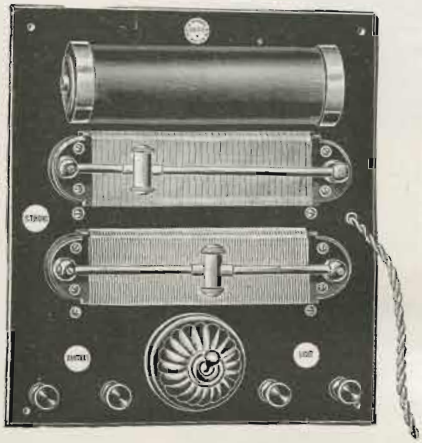
N. E. Aldridge, C. P. Ball, H. E. Bateman, J. Bark, R. A. Bickersteth, T. H. Bickerton, A. F. Blagg, W. F. Brook, A. Brown, J. E. G. Calverley, N. Davies, F. W. Daniels, J. Evans, E. J. Fox, H. E. Gamlen, O. S. Gogarty, T. O. Graham, P. N. Grant, V. T. Greenyer, W. L. Griffiths, T. D. Griffiths, T. Guthrie, P. A. Harry, E. M. Hanworth, P. S. Hichens, F. C. Hitchins, G. W. C. Hollist, C. T. Holland, A. G. Holden, B. S. Jones, H. L. G. Leask, D. M. Mackay, D. J. Macauley, J. Macintyre, P. McBride, P. J. McGinn, J. S. MacGregor, W. L. Muir, D. Neu, W. Overend, A. P. Parker, G. Potts, F. G. Proudfoot, J. D. Rawlings, J. Russell, A. W. Sandford, T. B. G. Smith, A. L. Turner, W. G. Turrell, R. H. Woods.

London, Doctors, etc.—P. H. Abercrombie, M. F. Agar, A. Allport, H. S. Barwell, G. W. Badgerow, L. L. Bathurst, L. W. Bathurst, R. M. Beattie, H. Braund, A. E. Bridge, R. W. Brimacombe, J. W. Bond, J. M. Brown, G. L. Cathcart, G. L. Cheatle, A. H. Cheatle, C. B. Clayton, H. H. Clutton, E. E. Cornaby, E. H. Crisp, E. P. Cumberbatch, B. Dawson, C. F. L. Dixson, R. W. Doyne, W. Edmunds, F. S. Eve, H. A. T. Fairbank, R. J. Ferguson, E. France, J. D. H. Freshwater, R. H. Fox, L. Galsworthy, K. W. Goadby, J. D. Grant, F. Green, E. C. Greenwood, Miss M. Hardie, J. E. Haslip, W. S. Hedley, H. T. Herring, G. Herschell, G. W. Hill, W. .J Horne, W. G. Howarth, F. H. Humphris, P. S. Jakins, G. J. Jenkins, H. M. Jones, J. C. Johansen, W. H. Kelson, E. Kingscote, R. Lake, E. Law, A. Lawson, W. M. Leslie, W. Lloyd, A. G. H. Lovell, H. J. Macevoy, G. W. Mackenzie, H. D. Mc Culloch, J. McGregor, J. P. D. McLatchie, W. McQuibban, H. H. Mills, C. W. M. Moullin, W. J. C. Nourse, A. Orwin, J. S. Part, C. A. Parker, L. H. Pegler, A. F. Penny, B. Pollard, J. Pollard, B. E. Potter, H. W. F. Powell, F. H. Preston, A. .W Read, P. Rendall, M. Rees, W. Rose, H. B. Robinson, E. W. Roughton, J. Russell Ryan, Sir D. Salomons, H. S. Sandifer, Mrs. A. F. Savill, S. Scott, Sir F. Semon, J. Shaw, A. J. Silcock, B. H. S. Spicer, F. Spicer, J. Startin, W. Stuart-Low, C. J. Symonds, I. Taylor, C. Thompson, H. Tilley, H. F. Tod, A. H. Tubby, H. F. Waterhouse, F. C. Wallis, A. Westerman, A. Wilson, G. H. L. Whale, T. P. Whittick, W. H. White, A. Whitfield, T. C. Wood, D. Wright, C. A. Wright, A. Wylie.

Colonial, etc., Doctors, etc.—L. A. Beck, A. M. Moll, J. Peterson, Cape Town, G. E. Murray, Dr. Petteval, E. Yeates, Johannesburg; E. C. Long, Maseru; A. Doyle, Brisbane; D. N. O'Brien, Rockhampton; J. Murphy, Melbourne; A. W. Munro, Sydney; L. A. Gagnier, Montreal; D. Juda, Bombay; G. V. Lockett, Vancouver; Dr. E. Reytter, Bangkok; Dr. Rudra, Calcutta; Medical College, Calcutta; Medical College, Madras; J. C. Dalmahoy-Allen, Hong-Kong; R. K. Jeffrey, Valparaiso; Dr. Boxer, Hastings, E. Rawson, Wellington, New Zealand; N. G. Munro, Yokohama; Dr. Irwin, Tientsin; Dr. Truhart, St. Petersburg; L. Joulia, Paris; W. Young, Cawnpore; J. Mc. N. Christie, Wanganui, New Zealand; D. L. Hubbard, Bordighera, Italy; Civil Surgeon, Cawnpore.

TRANSFORMERS TO USE THE ALTERNATING CURRENT FROM THE MAINS FOR SURGICAL LAMPS, GALVANISATION, ELECTROLYSIS, ETC.

(*See also pages* 35 and 44.)



No. 2050.

No. 2050. **Schall's Portable transformer** for cautery and surgical lamps, on enamelled slate plate. The current for cautery can be varied gradually between 8 and 20 ampères, and the current for surgical lamps from 4 to 15 volts, Fig. 2050 .. **£4 0 0**

Size, $9\frac{1}{2}$ by $9\frac{1}{2}$ by $2\frac{1}{4}$ inches.

No. 2052. **Similar Transformer,** but for cautery only **£3 0 0**

When ordering, please state the number of volts and the number of periods of your supply.

Polished wooden frame with glass door, to protect the transformer from dust, etc. **£1 5 0**

Our Transformer No. 2050 is now used by over 1000 medical men and hospitals, which is the best proof of its convenience and reliability.

No. 2054. **Portable Transformer,** for cautery, surgical lamps, and sinusoidal faradisation, Fig. 2054 .. **£6 0 0**

A Universal Apparatus, to use the **alternating** current for cautery, surgical lamps, galvanisation and electrolysis, sinusoidal faradisation; for operations with drills, for massage, air pumps, etc., will be found under No. 2008, page 147.

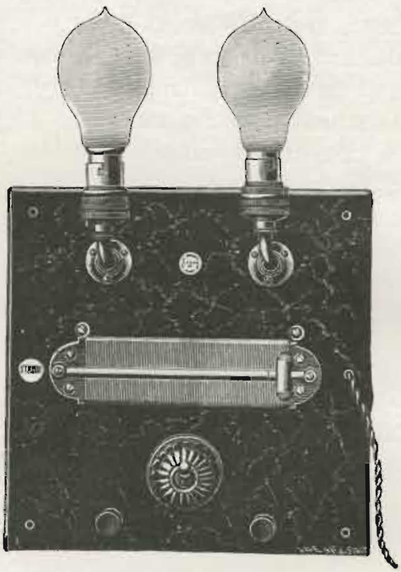
Motor Transformers, to convert the alternating into a continuous current, will also be found under Nos. 1780-1782 and 2682-2687.

No. 2054.

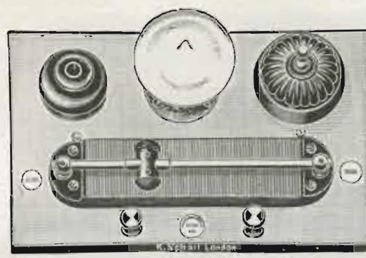
RHEOSTATS FOR SURGICAL LAMPS.

(*See also page* 41.)

These rheostats can be used equally well on a continuous or an alternating current. In ordering please mention the E.M.F. of the supply.



No. 2060.



No. 2066.

No. 2060. **Rheostat,** consisting of two lamps, sliding rheostat, switch, and terminals, mounted on enamelled slate, suitable for all sizes of surgical lamps, Fig. 2060 .. .. £3 0 0

No. 2066. **Portable Rheostat** for surgical lamps, Fig. 2066 .. £2 10 0

TRANSFORMERS FOR SURGICAL LAMPS.

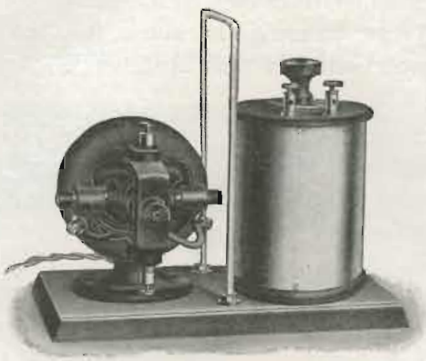
We have been frequently asked whether patient and operator are safely protected against a shock while the *rheostats* described above are being used. In a private consulting room, with a *dry* wooden floor, carpet, or linoleum, there is no risk of a shock unless the patient or operator touch a gas or water pipe. In Hospitals, however, with stone floors, there is a decided risk, especially when using cystoscopes, etc.

This danger does not exist if the illuminating instruments are connected with a *transformer*, like Pantostats Nos. 2005–2008; but as these instruments are somewhat expensive, we have constructed small transformers which give sufficient current for all sizes of surgical lamps.

No. 2070. **Portable Transformer,** to transform an *alternating* current for surgical lamps £3 0 0

Size—Diameter, 3½ inches, height, 6 inches.

In ordering please state voltage and periodicity of the supply.



No. 2075.

No. 2075. **Portable Transformer,** Fig. 2075, to transform a *continuous* current for surgical lamps **£6 10 0**

Size—5 inches wide, $8\frac{1}{2}$ inches long, 8 inches high.
Weight—8 lbs.

In ordering please state the voltage of the supply. The continuous current is changed into an alternating current by means of a small motor transformer, and the voltage of this alternating current is reduced by means of an alternating transformer. It can be varied easily to adapt it to all lamps requiring between 2 and 12 volts.

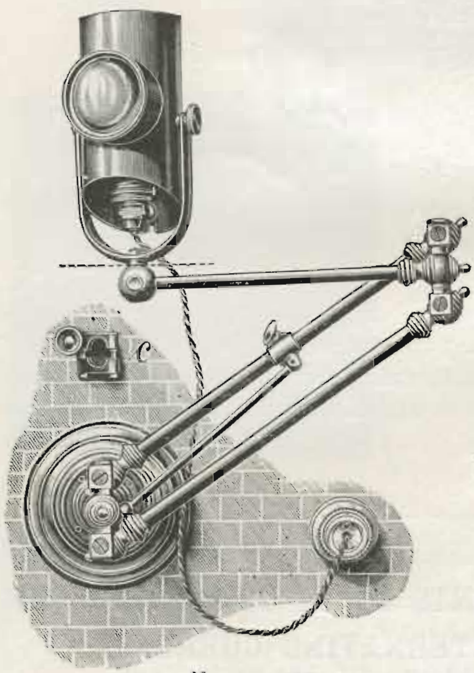
ILLUMINATING INSTRUMENTS TO BE USED WITH THE CONTINUOUS OR ALTERNATING CURRENT SUPPLIED FROM DYNAMOS.

In ordering these instruments it is necessary to state the voltage of the supply, and in some cases also whether it is a continuous or alternating current.

The Lamps Nos. 2090—2101 can be provided either with incandescent lamps, which have a carbon filament arranged in a zig-zag in the centre of the glass bulb (so-called focus lamps), or else they can be provided with Nernst lamps, which give a whiter light of 60 to 100 candle-power. As far as homogeneous illumination, *i.e.*, absence of bright or dark parts, is concerned, the light of these Nernst lamps is as good as the limelight, and the candle-power comes nearer the limelight than any other lamp which may be used. The disadvantage of the Nernst lamps is that, after turning on the switch, one has to wait nearly a minute till the light appears, and the burners are fragile (they are made of similar materials to the Auer-Welsbach gas mantles), only lasting for 200 to 300 hours.

It must be clearly understood that we do not hold ourselves responsible for these burners. When ordering the lamps it is necessary to state the voltage of the supply, and whether they are intended for a continuous or an alternating current.

The prices quoted for Lamps Nos. 2090, 2095, 2098, and 2101 are for the bull's-eye lanterns fitted with incandescent focus lamps; if it is desired that they should be provided with Nernst lamps, **5**/- has to be added to the prices.



No. 2090

No. 2090. **Dr. MacDonald's Lamp,** with bull's-eye, for throat, nose, and ear examinations, and for surgical operations. The lamps are movable in any direction, and can be taken off the bracket and used as hand lamps. Price, with parallel bracket, as shown in illustration, and with a 32 candle-power focus lamp, Fig. 2090 ..	**£4 6 0**
No. 2095. **Dr. MacDonald's Lamp,** as shown in Fig. 2090, but without the parallel bracket. A clamp (*c*) is supplied with it, by means of which it can be attached to an existing gas bracket ..	**1 15 0**
No. 2098. **Dr. MacDonald's Lamp** on a stand, to be put on a table, Fig. 2098	**2 5 0**
No. 2101. **Dr. MacDonald's Lamp** on a telescopic stand, as shown in Fig. 2101	**3 10 0**
No. 2104. **Nernst Lamp,** with lenses and concave mirror, on stand, Fig. 2104	**3 15 0**

No. 2104 can also be suspended from a bracket, as shown in Fig. 2105.

This lamp supplies a parallel or converging beam of light of great intensity, and is excellent for examination of larynx, ear, nose, etc.

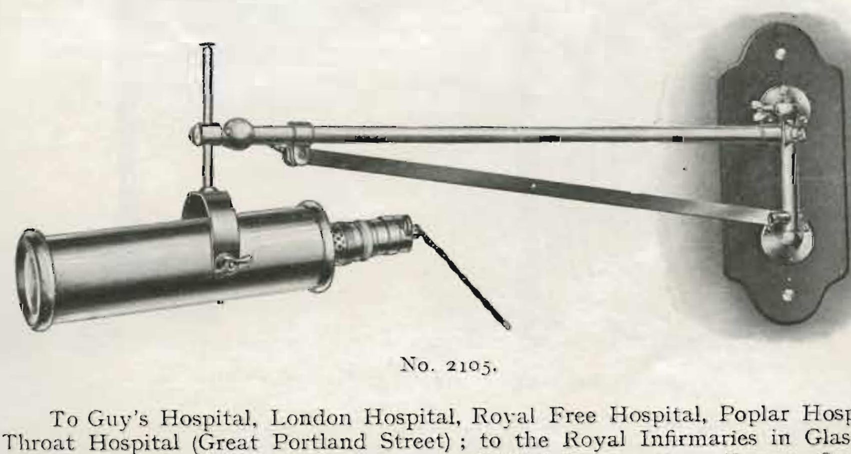
The Lamps Nos. 2090—2101 have been supplied by us, amongst many others, to :—

Dr. Greville MacDonald, Sir Francis Laking, Sir Victor Horsley, Sir Felix Semon, Dr. J. Macintyre, Prof. Ogston, and over 400 other surgeons.

No. 2104.

No. 2098

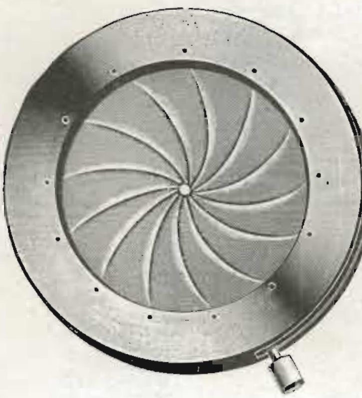
No. 2101.



No. 2105.

To Guy's Hospital, London Hospital, Royal Free Hospital, Poplar Hospital, Throat Hospital (Great Portland Street); to the Royal Infirmaries in Glasgow, Manchester, Aberdeen, Halifax, Wigan, Belfast, Newcastle-on-Tyne; Queen's Hospital and New General Hospital in Birmingham; Manchester Ear Hospital, Lincoln County Hospital, Royal Victoria Hospital (Bournemouth), etc., etc.

To the Governments of Natal, India, etc., etc.



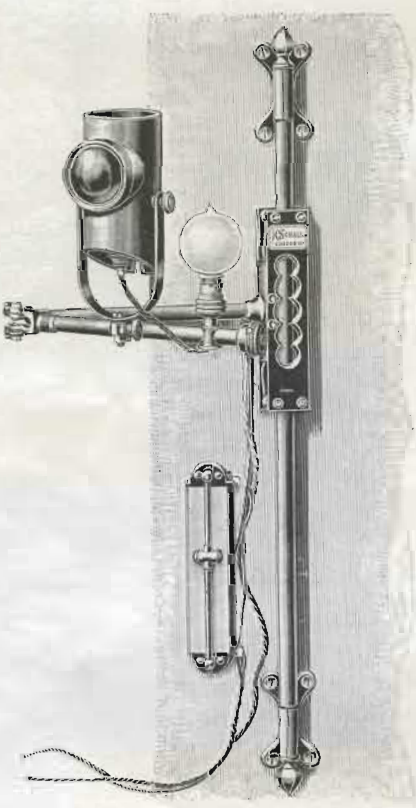
No. 2108.

No. 2108. **Iris Diaphragm,** Fig. 2108, with frosted glass plate **£1 0 0**

The bull's-eye lens of the Lamps Nos. 2090–2101 can be removed and the iris diaphragm can be inserted instead. The intensity of the light can be varied gradually by means of this diaphragm, *without varying the colour of the light*, which is important for ophthalmoscopic purposes. The frosted glass destroys any trace of the carbon filament.

No. 2114. **Ophthalmoscopic Bracket,** Fig. 2114, with frosted lamp and switch, **£4 0 0**

The Lamp No. 2095 can also be attached to this bracket, as shown in illustration, but is not included in the price quoted.



No. 2114.

No. 2125.

No. 2125. **Lamp on telescopic stand,** and mounted on a flexible metal spiral, movable in any direction, with reflector, Fig. 2125 .. .. **£2 7 0**

This is a very convenient lamp for an operating table; it gives a good light, can be brought close to the patient, occupies little space, and the reflector protects the eyes of the operator from the glare of light.

No. 2126.

No. 2127.

About fifteen of these lamps have been supplied by us to the new operating theatres of the London Hospital, and already many other hospitals are using them.

No. 2126.	**Reflector,** with 3 fifty-candle lamps, for surgical operations, mounted on strong stand with castors, Fig. 2126	£9 0 0
No. 2127.	**Large Lamp on telescopic stand,** with reflector, Fig. 2127	£3 0 0

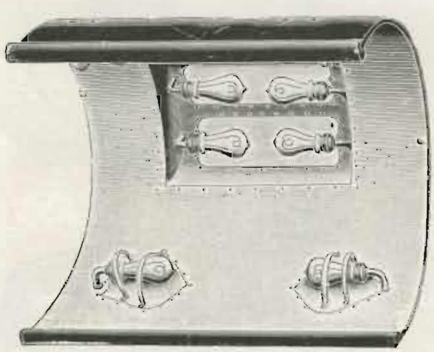
This lamp can be used either for illumination, for keeping exposed parts warm, or for small local light baths.

No. 2131.

No. 2131. **Hand Lamp,** with reflector and switch, Fig. 2131 .. £0 18 0

No. 2132.

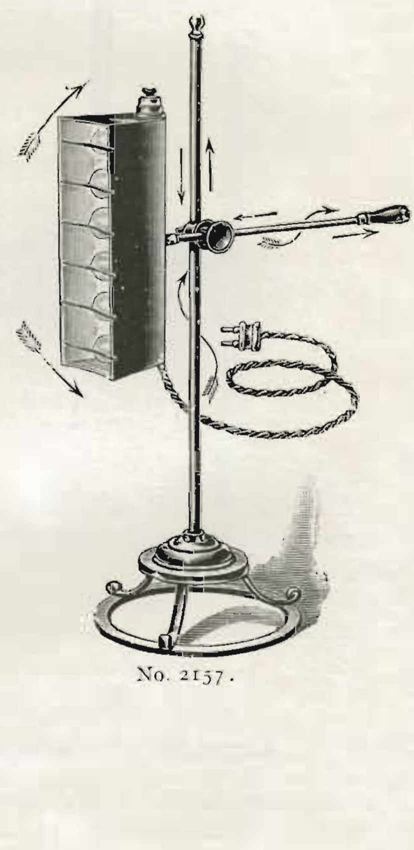
No. 2132. **Hand Lamp,** with reflector and switch, Fig. 2132 .. 0 18 0



No. 2165.

No. 2165. **Frame,** with twelve lamps, suitable for placing over a patient lying in bed, Fig. 2165 .. £9 0 0

No. 2157. **Reflector,** with six lamps, movable in any direction. Switch to turn on either three or six lamps, Fig. 2157 £7 10 0



No. 2157.

SMALL LIGHT BATH FOR LOCAL APPLICATIONS.

By Dr. Miramond de Laroquette.

The Light Bath, containing 6 lamps, consists of a drum-shaped box which opens like a pair of scissors. The maximum temperature which can be reached depends on the candle power of the lamps used; with 16-candle lamps it can be raised up to about 120 degrees.

It can be applied in various ways, as shown by the illustrations, and is especially useful in cases of pain due to rheumatic or gouty conditions, inflammation of joints, gall-stones, stiffness, etc. It can easily be applied to any part of the body. It is light and portable.

No. 2169. **Light Bath**, as described and illustrated **£5 15 0**

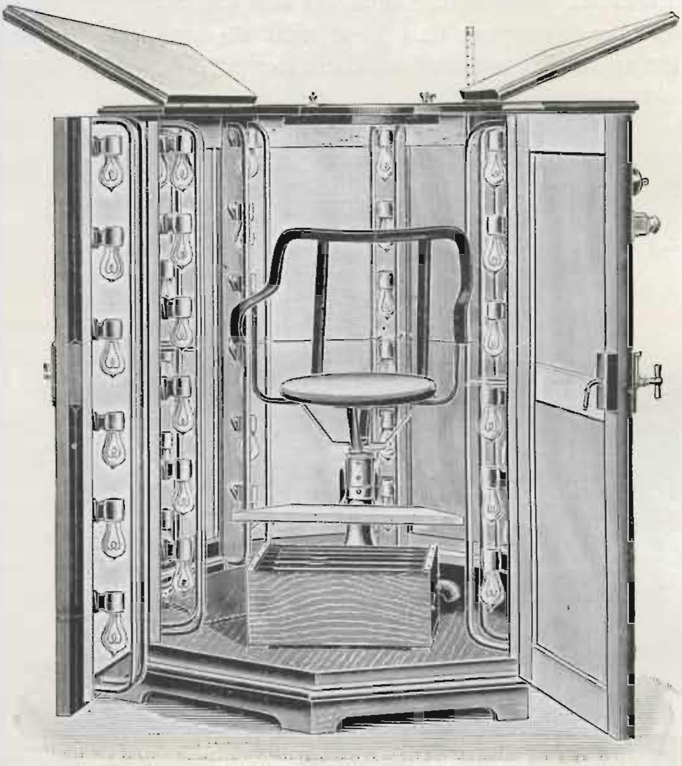
ELECTRIC-LIGHT AND HOT-AIR BATHS.

Light has an animating and exhilarating influence on human beings; it causes the pores of the skin to open, stimulates circulation, and kills bacilli. For these reasons sunlight is being used for therapeutical purposes in southern climates; but in our latitudes this is not possible, sunlight being too scarce and not reliable. Several medical men—Dr. Kellogg, of Battle Creek, Michigan, seems to have been the first—have, therefore, tried whether sunlight could not be replaced by electric light, and the result of these experiments was so favourable that apparatus for this kind of treatment have come into general use.

No. 2176—CLOSED.

Perspiration is produced by the light and the heat of incandescent lamps, a method which is preferable to the Turkish bath for several reasons: The perspiration sets in at once; the temperature can be conveniently and accurately regulated by varying the number of lamps in action; the temperature of the air which the patient breathes is normal, consequently *lungs and heart are not affected*, and the depression under which so many patients suffer in the Turkish bath does not appear. Although the temperature is higher, and the perspiration more profuse than in the Turkish bath, the patient has an agreeable sensation in the dry heat.

These light baths can be used equally well with a continuous or an alternating current. In ordering, it is necessary to state the number of volts of the supply, and, if arc lamps are desired, it is necessary also to mention whether the current is continuous or alternating.



No. 2176—OPEN.

No. 2176. **Prof. Winternitz's Light Bath,** Fig. 2176, with forty-eight incandescent lamps, six switches, and fuses to switch the lamps on or off in groups of eight lamps at a time; thermometer and chair, which can be raised or lowered. The sides are lined with porcelain plates, the floor is enamelled .. **£38 0 0**

Size: Diameter 4 ft.; height 4 ft. 4 in. The bath can be taken to pieces so that it will pass through any door, and it can easily be cleaned.

We have supplied the Light Bath No. 2176, amongst others, to:—

H.R.H. the Princess Royal, H.G. the Duke of Portland, Lord Rothschild, Lord Clan-William, Lord Farquhar, Lord Bentinck, Lord Kenyon, Prince Hatzfeld, Sir J. Ellis, Sir Alfred Hickman, the Hon. G. Lambton, Drs. Abbot, Anderson, F. Little, F. Mackenzie, J. Shaw, Messrs. Wertheimer, Singer, etc., etc.

To Guy's Hospital, the Bath Club in Dover Street, the Turkish Baths at Earl's Court, Wolverhampton, Birmingham; Hydropathic Establishments in Peebles, Rothesay, Tunbridge Wells, Helouan, and Sydney; the Corporations of Keighley, Dover, etc., etc.

All the light baths are lined with white enamelled plates, because they reflect the light and heat rays better than mirrors can do.

Most of the baths are fitted with incandescent lamps only, but some are provided with arc lamps as well. These arc lamps give a higher candle-power, but it is a mistake to suppose that their light is sufficiently powerful to kill bacteria ; the apparatus required for the latter purpose will be described later under Nos. 2315—2398.

The switches are arranged so that they can be turned on or off from the outside or the inside of the bath.

Coloured screens are added, so that white, blue, or red light can be used.

The door can be provided with a roll shutter, if it is desired to use a search lamp placed outside the bath.

Many combinations of light baths with arc lamps alone, or arc lamps combined with incandescent lamps, colour filters to be used with powerful search lamps placed outside the bath, are possible. The illustration shows a light bath with arc lamps, and door with roll shutter.

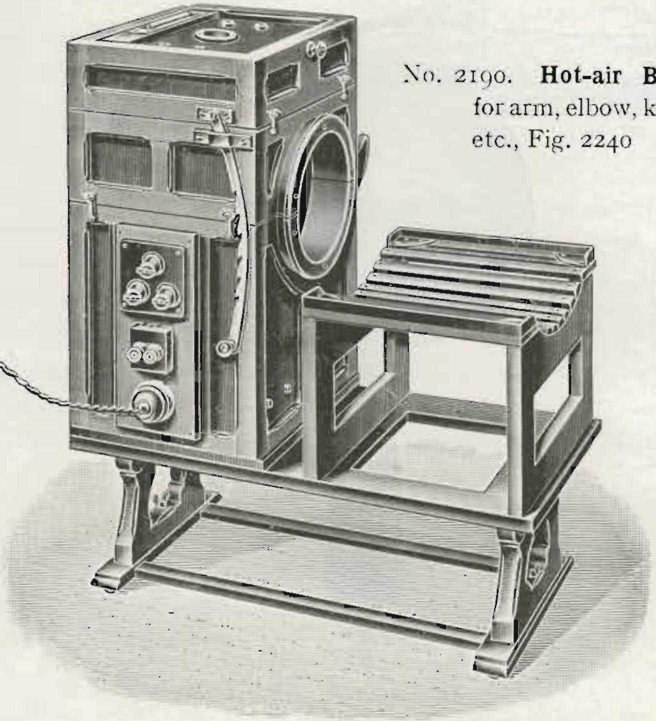
Estimates and illustrations will be sent on application.

The apparatus consumes a current of 6 ampères with 220 volts.

In the **Hot-air Baths** the temperature can be raised *gradually* up to 300, or even 400 degrees, by means of resistance wires arranged inside the bath. The illustration shows the apparatus which is being used most frequently for arms, knees, etc. Illustrations and estimates of other types of apparatus, suitable for the whole body, will be sent on application.

Dr. Tyrnauer's Hot-air Baths.

A special list about these baths can be had on application.



No. 2190. **Hot-air Bath,** for arm, elbow, knee, etc., Fig. 2240 **£20 0 0**

Fig. 2190.

HOT-AIR DOUCHES.

The hot air is generated by propelling air by means of a ventilating fan past a resistance which can be made incandescent by the current from the main. The apparatus consumes little current, and can be attached to any wall plug.

The temperature of the air close to the mouthpiece of the apparatus can be raised up to about 300 degrees, but it diminishes as the distance from the mouthpiece is increased. The quantity of air propelled by our apparatus is so great (about 300 litres per minute) that it produces the sensation of massage; the perspiration is carried off instantly. Hot or cold air can be obtained.

The hot air produces local hyperæmia, and is of great value in treating abscesses, erysipelas, and some infected and discharging wounds and skin diseases. The hot air dries up such wounds, the secretion ceases, and healthy new granulations soon appear. It is also most useful in many cases for relieving pain, and for treating bronchial catarrh.

The hot air douches are most convenient for drying hair, airing and warming linen or beds, etc.

In ordering, please state the voltage of your supply, and whether it is a continuous or an alternating current, in the latter case the periodicity of the supply should also be mentioned.

No. 2200.

No. 2200 **Hot-air Douche,** Fig. 2200, with small motor serving as hand-piece, ventilating fan, and connecting cords, 3 yards long **£1 18 0**

No. 2202.

No. 2202. **Glass Tube,** to be attached to the hot-air douche, with small reservoir which can be filled with perfume or drugs (Eucalyptus, Pinus Pumilis oil, etc.) which are to be volatilised by the hot air for inhalation, or for making the air sweeter, Fig. 2202 .. .. .. **0 16 0**

ELECTRO-THERMAL COMPRESSORS.

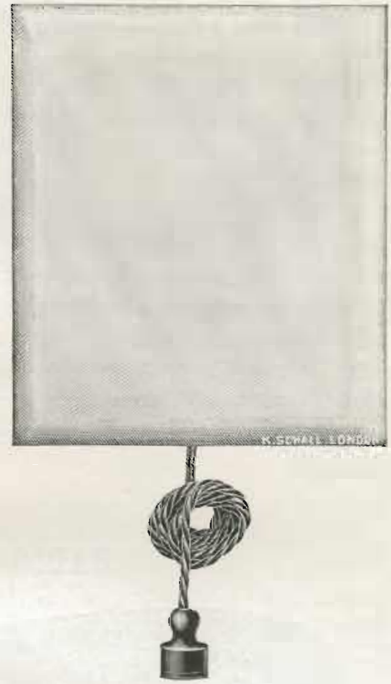
Dry heat, in the shape of radiant heat or electric-light baths, is being used so frequently, and with such great success, that it does not require any more special recommendation in many cases of cold, and in cases of a rheumatic or gouty nature, such as lumbago, sciatica, neuralgia, gout, rheumatism, etc. It relieves pain, reduces swelling, stimulates exudation and the circulation, etc.

Hot-air or Electric-light Baths are available in many hydros and special institutes: but in the majority of cases it will be more convenient, and cheaper, if the treatment can be applied in the patient's own home.

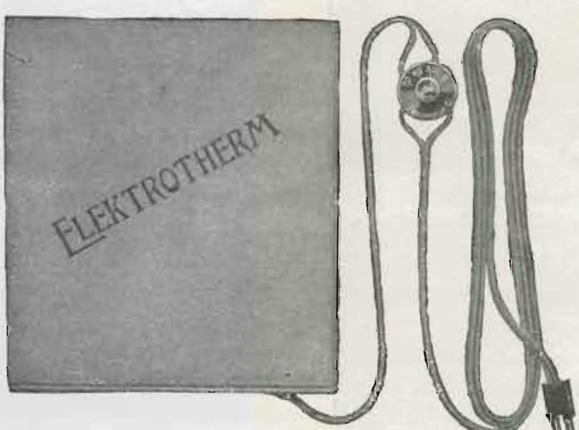
The apparatus required are neither costly nor cumbersome, but they can be used only in houses where the electric light is laid on. The Compressors consist of strings made of asbestos. Round these strings a fine resistance-wire is wound, and the strings are arranged in spirals between asbestos pads, which are enclosed in an outer cover, which can be removed for cleaning or renewal.

A switch is in the circuit to control the heat, which can be raised up to about 300 degrees Fahrenheit as maximum.

The Compressors can be made in various sizes and shapes: below is a list of those used most frequently :—



No. 2285.



FLAT COMPRESSORS.

No. 2280.	For the Eye	..	..	£0 10 0
,, 2281.	,, Throat	$2\frac{1}{2}$ins. by 14 ins.	..	0 15 0
,, 2282.	,, Heart	$8\frac{1}{2}$ins. by $12\frac{1}{2}$ins.	..	0 18 0
,, 2283.	,, Stomach	8 ins. by 10 ins.	..	0 18 0
,, 2285.	,, ,,	12ins. by 14 ins.	..	1 6 0
,, 2287.	,, Abdomen	7 ins. by 17 ins.	..	1 6 0
,, 2289.	,, Lungs	..	..	1 6 0

For the lungs, two flat Compressors of this size may be used *simultaneously*, one on the chest and the other at the back.

HOLLOW COMPRESSORS.

No. 2291.	Hand Bags	£1 9 0
,, 2293.	Bags for Elbow or Knee ..	1 10 0
,, 2295.	Bags for the Shoulder	2 0 0

Other sizes and shapes can be made to order.

Rheostat for any of these Compressors, with switch, giving three different degrees of heat .. 1 8 0

The Compressors can be used on any current, but in ordering it is necessary to state the voltage for which the apparatus is required.

The Compressors should be used near the skin; if they are covered with a blanket, or something similar, the heat cannot be carried off by the air, and the temperature will rise so high that blankets, etc., may become damaged.

RADIO-ACTIVE PADS.

No. 2300.

The startling results which have been obtained with pure radium preparations are well known, and it has been proved that many of the favourable effects to be obtained in spas in cases of nervous, neuralgic, rheumatic, etc., affections, are due to the radio-active properties of their mineral springs.

Our pads are filled with the best materials from which radium is extracted; they retain their activity for an unlimited time, but have not the destructive effects on tissues of the pure radium preparations. They are intended to enable patients to obtain at home the beneficial effects of radio-active spas.

The pads have been tested, and are *guaranteed* to have a power equal to 250 Mache units; this is more than the power given off by the most radio-active springs of Europe (Gastein has 150, Baden Baden 125, Castellamare 23 units).

The illustration shows the effect on a photographic plate. If a plate is wrapped in a light-tight envelope, and a radio-active pad with a key underneath left on it for twenty-four hours, a negative similar to the one shown in the illustration will be obtained on developing the plate. The pads are light in weight, pliable, and can be worn without discomfort during night-time or during the daily occupation. As long as they are not heated artificially, there is no danger of any burns. They *alleviate pain*, and have been used with great success in many affections of a nervous, neuralgic, rheumatic, etc., nature.

No. 2300.	Radio-active Pad, 8 × 12 in., Fig. 2300	..		£3	3	0
,, 2302.	,, ,, 6 × 8 in.	..	..	2	2	0
,, 2304	,, ,, 4 × 6 in.	..	..	1	0	0

Other sizes can be made to order.

APPARATUS FOR THE TREATMENT OF LUPUS, ETC.
By Prof. Finsen's Method.

The experiments made by Professor Finsen have shown that lupus and similar diseases can be cured by a very powerful light, provided that the tissues to be treated have been rendered anæmic, so that the light can penetrate far enough without being absorbed by the blood.

Prof. Finsen used large arc lamps consuming 50 ampères, and giving a light of about 10,000 candle-power. By means of lenses the light is concentrated on a small circle of about ½in. diameter, and to exclude the heat rays a stream of water circulates through the tubes which hold the lenses in their places. Four patients can be treated at the same time with one lamp, but the original pattern is a little wasteful.

Prof. Finsen and his assistant Reyn constructed, therefore, a smaller lamp on the same principles, the Finsen-Reyn lamp. The arc lamp of this apparatus consumes 20 to 25 ampères, is self-adjusting, and a concentrator provided with quartz lenses and water circulation, similar to the concentrators used in the larger lamps, but shorter, is in front of the arc lamp. Only one patient can be treated at a time. This type of lamp is being used most frequently now. The light of sparks from large Leyden jars can also be used; these condensers have to be charged either from spark coils, or from the alternating current from the main, with a step-up transformer. The light of these sparks is rich in ultra-violet rays. Ultimately, the light of mercury vapour lamps has been found to be very rich in ultra-violet rays, they are therefore suitable for this treatment, provided that the tubes on which the light is generated are pervious to the ultra-violet rays.

No. 2315.

Whatever lamp is being used, the tissues must be made anæmic by pressure, and for this purpose the compressors (lenses of quartz, or pieces of rock salt or ice) are pressed firmly against the skin, either by bandages or with the hand.

No. 2315. ***Finsen-Reyn Lamp,** consisting of arc lamp with automatic regulator, consuming 20 ampères, concentrator with rock crystal lenses and water cooling arrangement, mounted on telescopic stand, Fig. 2315. The arc lamp and concentrator can be moved in any direction **£32 0 0**

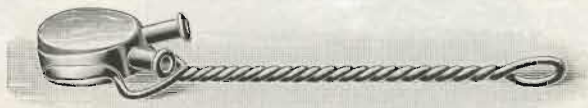
12 pairs of **spare carbons,** *best quality*	**£0 2 6**
100	**0 18 0**

Variable Rheostats, to use this lamp with the continuous current from the main, vary from **£3** to **£7,** according to the voltage.

It is possible to use the Lamp No. 2315 on an alternating supply if an electrolytic rectifier is inserted in the circuit. In such a case the arc lamp makes a slight humming noise.

* We have supplied our Finsen-Reyn Lamp, amongst others, to :—The War Office, the Crown Agents for the Colonies ; Charing Cross Hospital, Westminster Hospital, St. George's Hospital, Queen Alexandra Hospital, Skin Hospital, Stamford Street, London ; Royal Victoria Hospital, Belfast ; Infirmary, Cardiff ; Essex and Colchester Hospital, Colchester ; Skin Hospital, Birmingham ; Infirmary, Bradford ; Royal Infirmary, Glasgow, etc., etc.

No. 2326.



No. 2327.

No. 2319.

No. 2319. **Lens** for using sunlight for treating lupus, Fig. 2319 **£6 10 0**

The lens consists of two concave glasses mounted on a brass ring, the space between them to be filled with water. The optical part is suspended in a fork, mounted on a short telescopic stand movable in any direction.

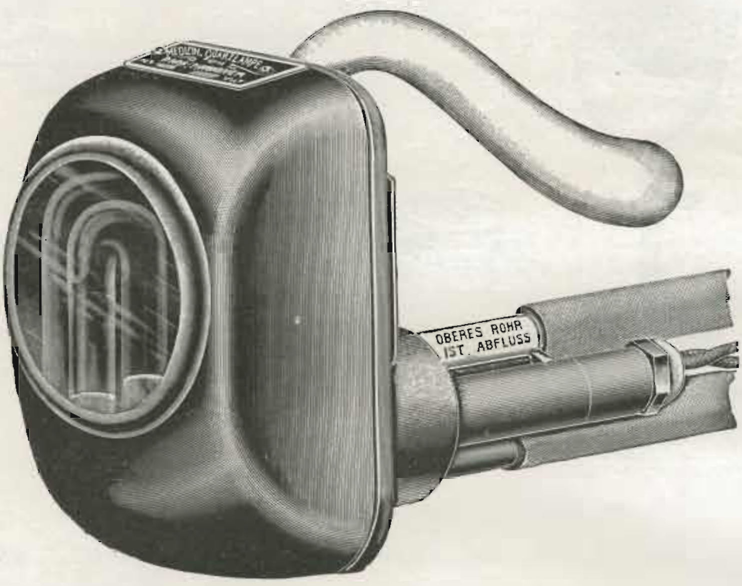
No. 2325. **Compressor,** consisting of two rock crystal lenses, mounted on a metal handle, with nozzles for connection with the indiarubber tubes for the water circulation **£1 15 0**

No. 2326. **Similar Compressor,** made specially for treating the eye, Fig. 2326 .. .. **1 10 0**

No. 2327. **Similar apparatus,** made specially for treating the lips and mouth, Fig. 2327 .. .. .. **1 10 0**

Operating-tables or Couches, to give the patients a comfortable position and adjust them to correct height, from **£4 10s.** to **7 0 0**

QUARZ LAMP.



Finsen's method of treating lupus with powerful arc lamps is now being employed regularly in many hospitals. Many attempts have been made to replace these large arc lamps by other sources of light, giving more ultra-violet rays, in order to shorten the exposure, and of all these the mercury vapour lamp enclosed in quarz tubes has been the most successful. It has first been described in the *Deutsche medicin. Wochenschrift,* No. 10, 1906, by Prof. Kromayer. He claims that, compared with a Finsen-Reyn Lamp, the Quarz Lamp produces the inflammation in half the time, that the penetration is greater, and as the area treated at one sitting is four times as great, while the current consumed is only 4 ampères, it is a great advance compared with the Finsen Lamp.

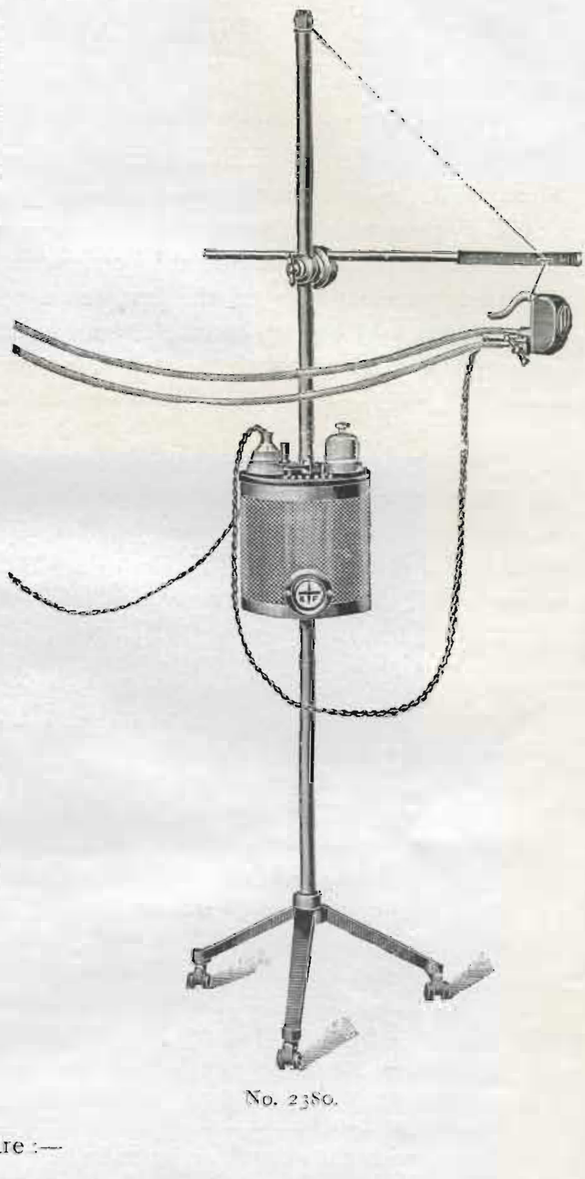
Since then other authorities—in this country the London Hospital and Dr. Heaton, of the Royal Sea Bathing Hospital, Margate—have tried the lamp and made comparative tests. All agree that the action on the surface is more rapid, that the penetration is great provided that a blue colour filter is interposed between lamp and skin to protect it from an overdose of the ultra-violet rays of short wave length. In the *Berliner klinische Wochenschrift,* Nos. 4 and 5, 1907, Prof. Kromayer reports good results obtained with this lamp in cases of nævi, lupus, eczema, etc., in which the Finsen lamp had previously been tried without success.

The chief advantages of the Quarz Lamp are :—

The mercury vapours contained in quarz tubes can be raised to a high temperature, and gives a powerful light which can be kept quite cool by the water circulation. The light is remarkably rich in ultra-violet rays, so that comparatively short exposures are sufficient. The lamp can be used at a distance of about 10 centimetres for treating the surface, or can be used as a compressor for affecting deeper lying parts. With the help of quarz rods of various sizes, it can be used to treat the mucous membrane of nose, rectum, vagina, urethra, etc. The area treated at one sitting is four times as large as that treated with a Finsen-Reyn Lamp, and it consumes only one-fifth of the current.

These advantages will certainly procure for this lamp a permanent position in photo-therapeutics.

It can be used on continuous current supplies of 70 or more volts.



No. 2380.

The prices of the apparatus are :—

No. 2380. **Quarz Lamp,** on floor stand, including variable rheostat, galvanoscope, cords, and india-rubber tubes, complete (Fig. 2380) . . . £28 0 0

As supplied to : London Hospital ; Royal Infirmary, Glasgow ; Royal Sea-Bathing Hospital, Margate ; Grimsby and District Hospital ; Research Department, University College, etc., etc.

APPARATUS FOR PRODUCING AND INHALING PURE OXYGEN.

(Patent applied for.)

This new and very simple apparatus consists of a glass flask, to be filled half-way with water, in which a quantity of permanganate of potash is dissolved. The hollow ground-glass stopper is provided at the lower end with a capillary tube which allows the oxygen developer which is to be poured into the stopper to drop slowly into the permanganate solution. Pure oxygen is generated immediately after the first drops reach the permanganate, and about 30 litres of oxygen become liberated gradually during the course of ten minutes. The process ceases when the fluid has become as colourless as water.

The oxygen can be inhaled by the patient through a metal mask, which is connected with the glass flask by an india-rubber tube.

In treating asthma, whooping-cough and other affections of the lungs, a few drops of menthol, pinus pumilis oil, etc., may be added to the water.

The price of the Complete Apparatus, consisting of glass flask, rubber tube, nickel-plated metal mask, and chemicals for 6 inhalations	£1	5	0
Chemicals for 6 inhalations	0	3	6
,, for 12 ,, ...	0	7	0

X-RAY APPARATUS
AND THEIR MANAGEMENT.

X-RAYS have become indispensable in diagnosis, and their importance for therapeutic purposes has grown beyond all expectation. The apparatus for their production have been simplified and made more convenient, but some medical men hesitate to employ them, and seem to be afraid because some electrical knowledge is necessary for success. This can certainly be acquired without much difficulty and loss of time, partly by reading and partly by demonstrations and experiments.

I have endeavoured to explain in the following pages the electrical and practical part, the physical laws, dosage, etc., and trust that it will be a help to many beginners. As Ohm's law has been explained already on pages 5 and 6, it will not be repeated, and those readers who are not quite familiar with it are referred to those pages.

Should anything of interest be found missing or not quite clear, I invite correspondence, or, if possible, a personal call.

For more convenient reference I have put the various tables referring to duration of exposure, comparing various standards, etc., etc., at the end, on pages 227–229.

W. E. SCHALL, B.Sc. Lond.

X-RAY APPARATUS

X-RAY APPARATUS.

In December, 1895, the scientific world was startled by the news of a discovery made by Professor Roentgen, of Wuerzburg. While experimenting with Crookes' tubes and fluorescent salts, he found that from these tubes there emanate rays which, though invisible to the eye, act like ordinary light on photographic plates, and moreover, that these rays penetrate substances through which ordinary light cannot pass,—for instance, wood, flesh, etc.,—while other substances, like bones or metals, are less transparent or quite opaque.

X-rays are generated by discharging electric currents between two metal electrodes which are suitably arranged in a sealed glass bulb, from which the air has been exhausted to a definite, high degree.

There is no conductor of electricity right through these tubes, as in incandescent lamps, but the current has to leap across an empty space a couple of inches wide, which offers such an enormous resistance that only currents of some 100,000 volts can overcome it and discharge across this gap. The X-rays tubes are therefore perfect insulators for the 100 to 250 volt currents supplied for lighting our houses, but these currents can, like all currents of low voltage, be converted into currents of high voltage by *transformation*. The transformers most frequently used are

SPARK COILS.

Spark coils are used almost exclusively. The essential parts of a spark coil are :—

A primary coil, consisting of a number of thin sheets of a special magnetic iron, round which about 100 turns of thick copper wire are wound. This is placed in a stout ebonite tube, to insulate it from the secondary coil. The latter consists of many thousand turns of thin copper wire wound in some 100 thin vertical sections.

The E.M.F. or spark length to be obtained from the secondary coil increases with the number of turns used, because the E.M.F.'s induced in all the single turns become added. By choosing the number of turns suitably, we can, for instance, transform a primary current of 200 volts to 50,000 or 100,000 volts, but the number of ampères are reduced in the same proportion, because though the numbers of the volts and ampères can be *changed* by transformation, the total energy can of course never be *increased*, as this

would be against the law of the conservation of energy. If the transformation could be effected without any loss, a current of say 200 volts and 10 ampères = 2,000 watt could be transformed, for instance, into 50,000 volts and 0·04 ampères (40 milliampères), which represents again 2,000 watt, but as losses occur in every transformation of energy by friction, radiation, the conversion into heat, etc., the current obtained under the above conditions will be between 25 and 30 milliampères only, instead of reaching to 40 milliampères.

To overcome the resistance of an air gap of :—

4″	8″	12″	16″
110,000	150,000	190,000	230,000 volts are necessary.

The spark length increases at a much quicker rate than the voltage ; 110,000 volts are necessary to produce a spark 4 in. long, but 230,000 volts, i.e., about double the voltage, give sparks 16 in. long already.

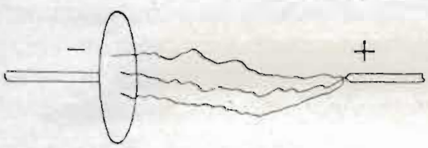


Fig. 1.

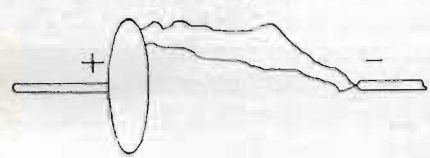


Fig. 2.

In the base of the coil is the condenser, whose function will be explained later on. The coils are provided with discharging rods ; one of these ends usually in a point, the other is provided with a plate, this arrangement helping to detect the polarity. The sparks can discharge easily from the point to any part of the plate while the latter is the *negative* pole or cathode, and the point the anode, or positive pole, as shown in *Fig.* 1. If the point were the negative pole, the sparks would invariably discharge between the *edge* of the plate and the point, as shown in *Fig.* 2, and would then be shorter than when discharging the correct way.

If we send a current through the primary wire, the iron becomes magnetized, and a magnetic field is created. The appearance or disappearance of this field, or any change in its intensity, induces currents of short duration in the secondary coil. Their intensity depends on the intensity of the magnetic field, and the *suddenness* of its appearance or disappearance.

There is a great desire to be able to give *short* exposures, as in many cases a *reliable* diagnosis is impossible if the exposure lasts longer than the patient can conveniently keep his breath. If an X-ray installation is wanted chiefly for therapeutic purposes, or to find fractures, dislocations, or a foreign body in arms, legs, etc., the quality and reliability of the picture need not be affected even if the exposure has to last three minutes, because an arm or foot can be kept quiet, and comparatively small coils will be sufficient. But if the apparatus is wanted for proving the presence of stones in the kidney, bladder, etc., of calcifications, tumours, tuberculous lesions, aneurysms, etc., the excursions due to respiration may make small objects disappear entirely, or cause the outlines to become so blurred that the negative would be insufficient for diagnosis unless we can finish the exposure in a few seconds ; in some cases it

is certainly a great advantage if the exposure need not exceed a small fraction of a second, to avoid even the movements due to the beating of the heart, the arteries, etc. If a negative of the stomach or bowels is to be taken, the exposure must not exceed a quarter of a second, to avoid loss of sharpness due to the peristaltic movement. To obtain X rays of sufficient intensity for such short or instantaneous exposures, *powerful* coils have to be used.

Size and Power of the Coils.—The intensity of the X rays generated in a tube depends on the strength of the current which we can send through the tube. The length of exposure depends, other things—like the distance between tube and plate, and the thickness of the object, and the penetrating power of the tube—being equal, entirely on the intensity of the X rays. With a current of 1 milliampère only, we have to expose twenty times as long as when we can use 20 milliampères with the same tube.

Spark coils have been classified up to now only according to the *length* of the spark which they can give. This is almost useless ; it means only that a coil has a sufficient *voltage* to overcome the resistance of an air gap 10 or 20, etc. inches long, but just as the power of a water-fall is not determined by the head of the water alone, but by the head × the *quantity* of water which is available, so for X rays the power depends on the number of volts × milliampères which the coil can give. To overcome the high resistance of an X-ray tube it is necessary to have a voltage not smaller than that required to overcome the resistance of an air gap 10 inches long, and as some spare power is desirable, coils giving sparks 12 to 18 inches long are most frequently used.

For some time coils giving sparks 24 inches long or more were considered preferable, but this was a mistake, because a higher voltage than that possessed by a 20-inch spark cannot be made use of, and the 7,000 additional turns of wire which would be required on the secondary coil to increase the spark length from 20 inches up to 24 inches would not only be wasted, but would tend to reduce the number of milliampères of the current on account of their resistance. It is a better plan to increase the diameter of the copper wire used on the secondary coil, as this reduces the resistance. It must be clearly understood that with a 24-inch coil which gives 2 milliampères only through a tube, the exposure will have to be ten times as long as, for instance, with a 16-inch coil which is capable of giving 20 milliampères through the same tube. Differences quite as great as this exist between various types of coils. They are due to the fact that in the better coils the size and proportion of the iron core, condenser, diameter and number of turns of wire, have been chosen more correctly than in the less efficient coils. This is generally admitted, and is the reason why all manufacturers claim that their coils give a "heavy" or "intensified" discharge ; but unless we have some means to measure and compare the output, we do not know at all which is a heavy, a heavier, or the heaviest discharge.

Measuring the Intensity of the Discharge.—Although it is not yet possible to measure the intermittent currents of high voltage obtained from spark coils as accurately as we can measure the currents from batteries or dynamos, it can be done, and it is of great importance that in addition to the spark length, the number of M.A. which a coil can give should be stated.

There are no convenient voltmeters for these currents available up to now, but even without a voltmeter we may obtain some information about the volts used. If we measure the M.A. obtained through a resistance of *known value*, we can calculate the voltage with the help of Ohm's law, e.g., 1000 volts produce a current of 1 M.A. in 1,000,000 ohms resistance. If the actual number of ohms is unknown, we cannot express the output in volts and ampères any more ; but provided that we use for comparison a suitable *standard resistance, which remains uniform, the number of M.A. obtained shows which coil and interrupter gives the largest output.*

The most natural thing would be to measure the number of M.A. obtainable through an X-ray tube, but as a standard of comparison this is impossible for several reasons, the chief of which is that there is too great a difference in the resistance of various tubes : the hard ones, suitable for examination on the screen, have over five times as much resistance as the soft ones, which are suitable for making negatives of hands, etc. Statements that a coil is capable of producing so and so many M.A.'s on a tube have no meaning unless the *exact degree of hardness is known*, and it is not possible to measure this as accurately as, for instance, the temperature can be measured ; the hardness of the tubes changes also frequently, especially with heavy currents.

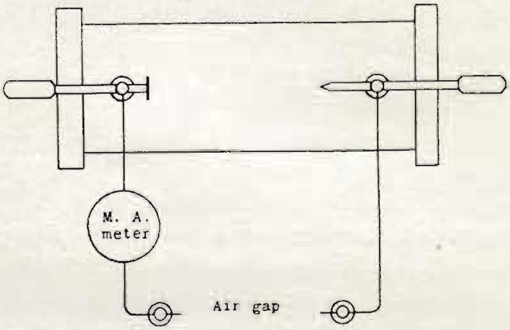


Fig. 3.

Statements that a negative of the heart, etc., can be reached in such and such a time are also subject to the widest fluctuations, as explained on page 231.

We can, however, measure the number of M.A. obtained through an air gap. Its resistance depends on its length, and we have to adopt, therefore, a definite length as standard. I would suggest 8 in. or 20 ctm. as suitable, because this is the length of the equivalent spark gap of the hardest tubes, and the smallest coils used in X-ray practice still give 8-in. sparks. Atmospheric conditions, or the shape of the electrodes (point, ball, etc.), do not affect the result as long as the latter are less than 10 mm. in diameter. The M.A. meter is not to be inserted in the air gap on the coil, it would be damaged if this were done ; it is to be connected as shown in the sketch. If a separate spark gap is not available, a temporary one can be arranged easily with the help of two empty bottles, the corks of which serve to hold the wires.

I have found that coils giving 20 milliampères through such an air gap give nearly twice as much current through a tube as coils which give only 10 milliampères, and although this proportion may change, *those coils which give the highest number of milliampères through the air gap always give the highest number of milliampères through a tube.* The air gap acts also as a valve, and excludes the reverse current, so that the reading is not disturbed by it.

This method gives us fair information about the real power of a coil, and is infinitely more accurate than the mere statement of the spark length. It is so simple that every owner of a spark coil and M.A. meter can use it.

It is also desirable to know the primary current required to produce a certain number of milliampères through the air gap. A difference of a few hundred watt more or less in the primary current is unimportant as far as the

bill for electricity is concerned, because the coils are required for a short time only. But coils which require a weak primary current only to give say 70 milliampères in the secondary circuit, enable us, in consequence of their better construction, to reach a larger maximum output than those coils in which a heavier current is required in the primary circuit. Moreover, with the latter coils the interrupters become hot, and the mercury has to be cleaned after a shorter time than with the former coils.

INTERRUPTERS.

The function of the interrupter is to close and open the primary circuit in regular succession. It should keep the primary current closed just long enough to allow the iron core to reach the maximum of magnetization ; the break should be as rapid as possible, and there should be a sufficient interval to allow the iron core to be demagnetized before the current is closed again. The more or less perfect manner in which these conditions are fulfilled influences the intensity of the secondary discharge which can be reached with various types of interrupters.

The condenser is connected in parallel with the interrupter ; it helps to reduce the spark appearing in the interrupter on breaking the primary current, and to demagnetize the iron core rapidly. It is of great importance for all coils connected with mercury breaks, but it is unnecessary for electrolytic breaks.

The first interrupters were of the hammer type, well known from faradic batteries or electric bells. Owing to their low efficiency they have been superseded, but on account of their great simplicity they are still used in some portable coils worked by accumulators.

Mercury Interrupters.—The motor-driven mercury interrupters are most frequently used. There is a large variety of them. The interruptions take place under alcohol or paraffin oil, in order to extinguish more rapidly the spark which appears at the breaking point than air would do. In some interrupters coal gas is used for the same purpose. The best frequency is 40 interruptions per second ; less than this would cause the light on the screen to be unsteady, and a higher frequency is bound to increase the amount of reverse current, and is an unnecessary strain on and waste of tubes.

I should like to mention here, too, that it is impossible to obtain the *best* results, unless the size of the iron core, the capacity of the condenser, and the frequency of the interrupter are adapted to one another.

Electrolytic Interrupters.—An interrupter based on a totally different principle was invented by Prof. Wehnelt, in Berlin, in 1899. In this interrupter a thin platinum wire and a large lead electrode are immersed in diluted sulphuric acid, 1 oz. acid to 5 oz. water, or 20 to 25° Baumé. When a current of at least 50 volts and 5 ampères is passing through this in such a manner that the

platinum is the anode, the density of the current is so great near the small anode that it becomes very hot, and steam is formed. In addition, electrolysis causes hydrogen and oxygen to appear, and these gases form an insulating mantle round the anode, which interrupts the current. If there is a sufficient amount of self-induction in the circuit, a spark appears at the breaking point, i.e., the anode, ignites the gases, and the explosion gives the acid access to the platinum, thus closing the current again. This process takes place with extraordinary rapidity and regularity. The intensity of the discharges and the frequency of the interruptions can be varied in the widest limits by varying the E.M.F. used in the primary circuit, the surface of the platinum anode, and the amount of self-induction.

The electrolytic interrupters are undoubtedly very good in every way ; they are the simplest interrupters, and require no cleaning and less attention and repairs than any others. They were used almost exclusively on the Continent and in America for over ten years, but there is an undeserved prejudice against them in this country. It is due to the fact that they were connected with coils which were not suitable for them. The self-induction and the voltage in the primary coil must be variable in order to have an efficient control over an electrolytic interrupter, and this makes two extra switches necessary on the switchboard. This is a disadvantage in some hospitals, where the Staff using the apparatus changes frequently ; but I am certain that every medical man who attempts to do so is able to learn the management of an electrolytic interrupter in half an hour.

One great advantage, however, offered formerly by the electrolytic interrupters has disappeared. Up to a few years ago the shortest exposures could be reached only with electrolytic interrupters ; but they remained stationary, whereas the mercury interrupters, and the coils wound for them, have been improved steadily, so that at the present time good negatives of any part of the body can be obtained with either type of interrupters, even in a small fraction of a second.

Interrupters for Alternating Current.—There are numerous interrupters, mechanical and chemical, which enable us to use the alternating current directly. None of them is as efficient as an interrupter on a continuous current, and the maximum intensity which can be reached even with the best alternating current interrupter is much weaker than that obtainable with a continuous current. But where the X rays are chiefly required for therapeutic purposes, or examination on the fluorescent screen, or if time exposures lasting up to five minutes can be given, several of the mechanical interrupters will be found satisfactory, provided that the supply has not more than sixty periods. With a higher periodicity than sixty most of these interrupters become impossible.

The chemical rectifiers consist of large cells containing aluminium plates, and iron, lead, or carbon plates as indifferent electrodes, in a solution of bicarbonate of soda. A current can pass freely through such a cell while the aluminium is the anode ; but if the direction is reversed, a thin layer of aluminium hydroxide is formed instantly in consequence of electrolytic action, and

this may offer a resistance of over 1000 Ohms to the passage of the current. This is used to convert an alternating into a pulsating unidirectional current. If the aluminium is quite clean, and while the cells are new, the rectifying effect is good, and for this reason this method has been tried again and again ; but to maintain the oxide in good condition the cells should be used *every day*, they require thorough cleaning from time to time, and nearly all the installations in which these cells were used for X rays proved unsatisfactory after a few months.

Motor Transformers.—We can, however, obtain with an alternating current exactly the same results as with a continuous current, if we convert it into a continuous current by means of a motor transformer. A motor driven by the alternating current is coupled to a dynamo which delivers a continuous current ; the size ought to be chosen so that about 1000 watt can be obtained from the latter. These motor transformers are very reliable, easy to work, have practically no wear and tear, and require scarcely any attention. They can be placed in the X-ray or any other room, or the basement, but should have a good bed-plate, and should not be fixed on a hollow resounding board.

The **Cooper Hewitt Mercury Vapour Lamps** might also be used to rectify the alternating current, but I do not consider them to be as good, owing to the wear and tear and the fragile nature of the lamps. Even when most carefully treated they have to be renewed after 500 to 1000 hours, and there is great risk of breakage in transit, because the mercury is contained in glass tubes from which the air has been exhausted. Any quick tilting of a box will cause the mercury to smash the glass, and a new lamp costs £5. The original cost of a complete apparatus is only a trifle less than that of a motor transformer, and in the long run the mercury vapour lamps are bound to be the more expensive.

High Tension Transformer without Interrupter.—There is yet another way of utilizing alternating (or transformed continuous) currents for X-ray purposes. It can be transformed into a suitable high voltage by means of an alternating transformer, and the waves made unidirectional by means of a high tension current reverser driven by a synchronous motor.

This method was invented and described by a Mr. Koch, in 1904 ; for peculiar reasons it remained dormant for some years, but has been taken up again lately.

It looks at first sight as if we could employ currents of almost unlimited intensity, but practically a limit is placed on the size and power of the transformers to be used, because they heat the tubes to a larger extent than spark coils do. This is the stumbling-block, and prevents us from using transformers larger than about 4 kilo watt. The greater heat is due to the different character of the discharge obtained from transformers connected with an alternating current compared with that obtained from coils with interrupters. With the latter we have a sudden break, an intense discharge of high voltage but short duration, followed by a comparatively long period of rest before the next discharge takes place. With an alternating current transformer we obtain waves of lower voltage, which are rising and falling *gradually*, but with almost no period of rest between two succeeding waves. On account of the difference in the voltage, a tube connected to a

spark coil gives rays of a higher penetrating power than when the *same tube* is connected with an alternating current transformer, and for therapeutic purposes, where hard rays are indispensable, coils are better.

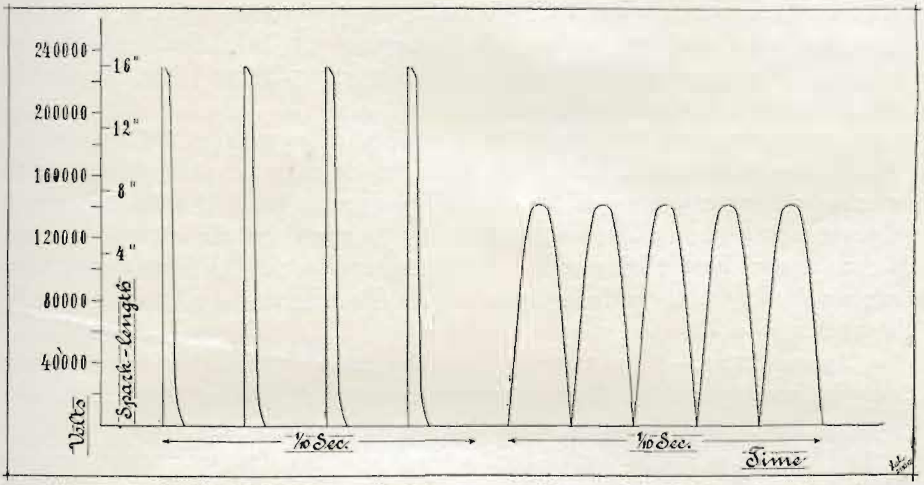


Diagram of the Discharges from Spark Coils. Fig. 4. Diagram of the Discharges from Alternating Current Transformers.

X rays of sufficient hardness to penetrate the glass are generated only while the E.M.F. of the discharge has a definite, high value. With a spark coil this high E.M.F. exists practically *during the whole duration of the discharge* ; with the interrupterless alternating transformer the E.M.F. has a sufficiently high value only *during the short time the wave is near its height,* the beginning and end of the waves are lost for the production of useful X rays ; but nevertheless they influence the M.A. meter (this is more fully explained on page 202), and for this reason the *quantity of X rays produced per M.A. of current is higher with coils, than with the interrupterless alternating current transformers* ; the M.A. produced with the latter have a lower value. The greater heat is due to the same reason, i.e., the fact that, *to generate the same quantity of X rays, more current has to be used with a transformer than with a coil and interrupter.* This can easily be proved by experiment. The illustration shows two positives obtained from negatives of an aluminium ladder, taken with the same tube and the same number of M.A. seconds.

A

B

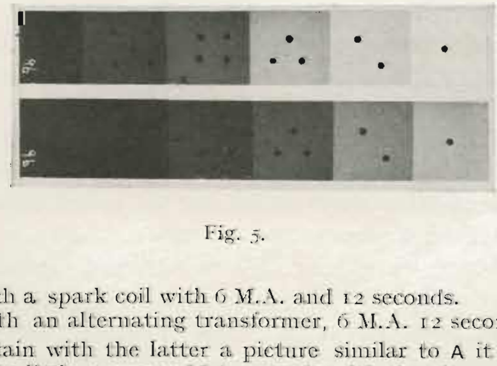


Fig. 5.

A was taken with a spark coil with 6 M.A. and 12 seconds.

B was taken with an alternating transformer, 6 M.A. 12 seconds.

In order to obtain with the latter a picture similar to A it was necessary to give an exposure of a little over 300 M.A seconds with the alternating transformer.

ELECTRIC SUPPLY.

We have yet to mention the sources of electrical energy which are necessary to work the spark coils. Wherever the continuous current is laid on this should be used ; it is the most convenient, and also the most efficient current. For mercury interrupters we require generally up to 12, for electrolytic interrupters up to 20 ampères.

If an alternating current with a periodicity of 40 to 60 is laid on, and the X rays are not wanted for short exposures, it may be used directly with mechanical interrupters. If the periodicity exceeds 60, or if only moderately short exposures are desired, it is necessary to transform the alternating into a continuous current by means of a motor transformer, as has already been explained on page 182, or a high-tension transformer without interrupter may be used.

Accumulators.—If no current from the main is available, accumulators may be used, provided there is an opportunity of getting them recharged easily ; but it must be understood that the time of exposure required will be somewhat longer, because with twelve 2-volt accumulators we cannot produce the same intense discharge which can be obtained with a 100- or 200-volt supply. If there is no opportunity of getting accumulators recharged, 12 *large* bichromate cells may be used too ; but if the apparatus is required frequently, the recharging of bichromate cells will be too troublesome and expensive. In such cases—

Gas or Oil Engines can be used very well to drive a dynamo. The oil motors are similar to those which are used in automobiles ; they can easily be started, and are small and portable, so that they can be used also in field hospitals. For a coil with a mercury break, engines of $1\frac{1}{2}$ or 2 H.P. are sufficient ; for electrolytic breaks 3 to 4 H.P. will be required. These engines may be used also for lighting small hospitals, or private houses. Some 30 metal filament lamps of 25-candle power can be used simultaneously with such an installation. A battery of 27 accumulator cells of about 75 ampère hour capacity, and a switchboard, are necessary in such cases. According to the number of lamps and the time for which they are used, the accumulators have to be charged once a week or once a fortnight for a few hours.

A Switchboard is required in most cases. These consist of marble plates, on which are mounted a main switch to turn the current on or off, and a variable resistance to control the intensity of the discharge. In most cases they are provided with volt and ampèremeter to measure the primary current, with a switch and rheostat to control the motor of the interrupter, a signal lamp to indicate whether they are turned on or off, and always with the necessary fuses and terminals.

In more elaborate installations the switchboard can be provided also with a switch to insert either a mercury or an electrolytic break, and to use the anodes of the latter separately or connected in parallel, with a switch to change the degree of self-induction of the primary coil, and with a switch and clock-

work to break the primary current automatically after a previously set time, which can be varied from 0·05 up to 10 seconds.

Shunt or Series Rheostat.—The switchboards can be so arranged that the coil is "in series" or "in shunt" with the dynamo. In the former case the full voltage of the supply has to be used, and can be reduced a little only by inserting resistance; in the latter case, the voltage can be reduced and varied gradually. This has decided advantages, if moderate or weak currents are required, because the variable voltage gives a better control over the discharge. For instance, with a 16-in. coil, a mercury break and a resistance of 35 ohms on a 240 volt supply, the shortest spark I could obtain "in series" was 5½ in. long, i.e., the discharge rods had to be separated 5½ in. to prevent the sparks from discharging; whereas the shortest sparks obtainable with the same resistance arranged in a "shunt" were only 1½ in. long. With a shunt the discharge can therefore be varied in wider limits, and it can better be adapted to medium and soft tubes than this is possible with the series connection.

As the amount of reverse current generated is in direct proportion to the voltage used in the primary coil (see page 194), we obtain less reverse current with the lower voltage available with a shunt than with the higher voltage which is inseparable from the series connection. The tubes have therefore a longer life when used with the shunt connection, which is consequently more economical, and to be preferred for all time exposures and for therapeutic purposes, i.e., whenever moderate or weak currents have to be used for a comparatively long time. Long practical experience, and the fact that the quality of the X-ray pictures obtained in the early days, when 12-volt accumulators only were used, has never been exceeded, is also a proof that a low voltage in the primary coil is preferable to a high one as far as the quality of the negatives and the lifetime of the tubes is concerned.

There are, however, cases in which short duration of exposure is of greater importance than regard for the lifetime of the tubes, to avoid the loss of sharpness due to the movement of the heart, stomach, etc., or in taking restless children, and the full voltage of the main has then to be used, as more milliampères can thus be reached than with the reduced voltage, and in all such cases the series connection, without any resistance in the circuit, is better than the shunt connection.

The objection to shunt rheostats is that they are wasteful. They are a little more expensive, and the rheostats, while in shunt, consume twice as much current as they will do while in series; but everybody who uses X rays for a short time only knows that the bill for the current is a negligible quantity compared with that for the tubes, and the latter is most decidedly heavier with a series than with a shunt rheostat. The better switchboards are so arranged that the coil can be placed in "shunt" or "in series" at the will of the operator, by closing or opening an additional switch which is marked "Shunt."

FOCUS TUBES.

The quality of the focus tube is all important for success in X-ray work : if the tube is unsuitable, too hard or too soft, it is impossible to obtain a good negative, even if the tube were connected with the very best electrical apparatus. On the other hand, if the tube used is a good one, a fair negative may be obtained even if the electrical apparatus is not quite perfect. Focus tubes deteriorate by use, and are expensive, but those which are properly treated will last for hundreds of exposures, whereas with carelessness or want of skill and knowledge, a tube may be damaged or even destroyed during the first exposure made.

It is therefore well worth while to devote a little more space to a description of the construction, working, and management of the tubes.

Cathode Rays.—If the secondary terminals of a spark coil or other source of electricity of *high voltage* are connected with electrodes which are fixed in a glass tube from which the air has been exhausted, a current will discharge through such a tube rather than through the surrounding air. The current passing between the two poles takes the form of a stream of very numerous and very small negatively-charged particles. These particles are believed to be finite quantities of electricity separated from all other matter. They are called electrons, and the stream of these electrons is called cathode rays. They travel in a straight line with a velocity almost as great as that of light. This velocity increases with the E.M.F. with which the cathode is charged, and with the degree of exhaustion. If this is great, we call the rays " hard," if it is comparatively low, we call them " soft."

The cathode rays can be deflected from their path by a magnet. If they are arrested in their flight by a hard substance, like the glass wall of the tube, or the metal of the electrode, they produce in consequence of their great velocity intense heat, in spite of the fact that they must be smaller yet than even the atoms of hydrogen. They cause fluorescence of the glass, but do not penetrate through the glass.

Roentgen Rays.—When the cathode rays strike a hard substance—for instance, a piece of metal placed in their way,—they are converted into X rays, and, provided that the E.M.F. used and the degree of exhaustion of the tubes are high enough, the X rays penetrate through the glass wall of the tube. They spread from the point of origin all round in straight lines, but they cannot be reflected, or refracted, i.e., be focussed by a lens, and they cannot be deflected by magnets.

Their intensity diminishes in inverse proportion to the square of the distance, and though invisible to our eyes, they affect bromide of silver like ordinary light. They make some substances—for instance, barium platinocyanide—fluorescent. They can penetrate through substances through which ordinary light cannot pass ; the amount of penetration depends on the hardness of the rays, and on the atomic weight of the substances through which they pass : cardboard is more transparent than wood or ebonite, flesh more than

bones, aluminium is fairly transparent, but the heavy metals are opaque. These properties make the X rays useful for medical and surgical purposes.

Construction of the X-ray Tubes.—The illustration shows the arrangement of an X-ray tube. The cathode, consisting of aluminium, is placed in the cylindrical part of the tube, and is given the shape of a concave mirror, in order to concentrate the cathode rays to one point. This is necessary in order to obtain sharp outlines of the shadows projected on the fluorescent screen or photographic plate; if the X rays were to emanate from several points, or from a large surface, the image would be unsharp or blurred. In the centre of the tube, and in the focus of the cathode, is a piece of metal called the anticathode. The surface of this consists of platinum. Comparative tests have shown that the largest quantity of X rays is obtained when the target for the cathode rays consists of platinum or platinum-iridium. Metals with a higher melting point, like osmium, tantalum, etc., have been tried, but in spite of

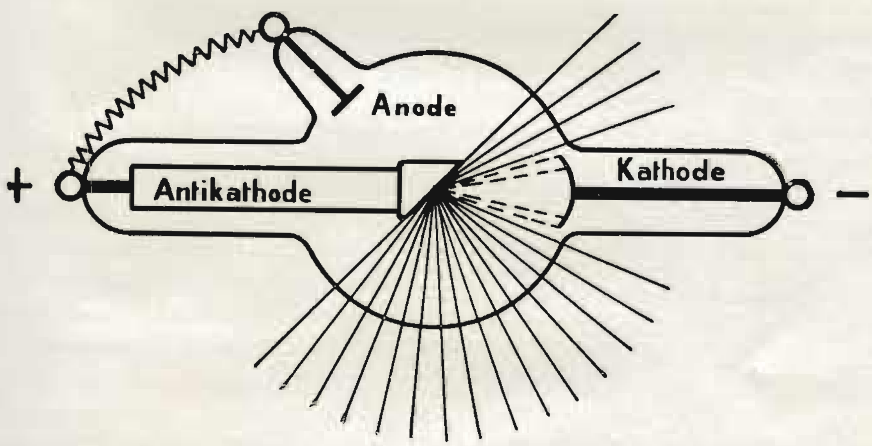


Fig. 6

this advantage they have been given up again; a *high atomic weight* of the metal used for the target is more important than the highest possible melting point. As solid blocks of platinum are out of the question, owing to the price, thin sheets of it are fused in intimate contact with a solid block of another metal, like nickel, copper, silver, etc., which can carry the heat off rapidly and disperse it by radiation. In some tubes water is used for carrying off the heat.

The anode shown in the illustration is a third electrode, which is required during the process of exhaustion. It is not necessary when the tube is being used, but usually anticathode and anode are connected by a wire outside.

Connecting the Tubes.—The cathode, i.e., the concave aluminium mirror of the tube, has to be connected with the *negative* pole, and the anticathode or anode with the *positive* pole of the coil. On page 177 it has been explained how the polarity of a coil can be found out by watching the behaviour of the sparks. If the X-ray tube is connected correctly, one-half of the tube—

the space between cathode and anticathode—looks as if it were filled evenly with green air, the other half of the tube behind the anticathode remaining dark, because the latter acts as a screen. If connected wrongly, there is an irregular patchy fluorescence on the glass walls of the tubes ; rings appear, and in such a case *the connection should be altered immediately, as the tubes are damaged if the current discharges in the wrong direction for any length of time.*

Penetration : Soft and Hard Tubes.—If we hold a cardboard screen coated with barium platino-cyanide in front of the anticathode, and turn the current on, the screen will fluoresce with a green-yellow light. If we hold a hand between the tube and the screen, so that it is close to the back of the screen, and 10 to 20 inches in front of the anticathode, a shadow of the hand appears on the screen. If the degree of exhaustion is comparatively low, the whole hand appears as a black mass, the tube is " very soft." If the vacuum is somewhat higher, the flesh of the hand becomes somewhat transparent, the bones appear as black shadows, and the wrist bones as a compact black mass ; such a tube is called " soft." With " medium " tubes, the wrist bones become clearly visible. If the vacuum is high, the bones are transparent too, and appear as grey shadows only, the flesh seems to have disappeared, the rays have a high penetration, and such a tube is called " hard."

In soft tubes the fluorescence is intensely green, with some tendency to blue light near the cathode. Medium tubes show a steady green colour, with usually sharp division between luminous and dark part, no violet light nor rings or irregular patches. In hard tubes the light is thin, grey-green, there are some irregular flame-like green spots on the walls of the glass, the tube makes a peculiar crackling sound, and the wires leading to it show lively brush discharges. If the tubes are very hard, sparks begin to discharge outside, and frequently pierce and destroy a tube.

The penetrating power does not depend on the amount of current we use in the tube ; the quality of the rays remains the same whether we use 1 or 5 M.A., but the quantity increases as we employ stronger currents. If, however, the voltage is raised, the penetrating power increases, and for this reason one and the same tube may be soft with one apparatus giving a comparatively low voltage only, and hard with another apparatus supplying a higher voltage, and medium with another.

Measuring the Penetration.—To obtain a good quality negative, *it is all important that a tube should be used with a penetrating power suitable for the object to be examined.* If it were too low, the X rays would be absorbed and stopped by the tissues, and would not reach the plate. If the tube used is too hard, fine details like the structure of the bones, calcifications, tumours, tuberculous lesions, small stones in the kidney will become transparent too, and disappear entirely. It is therefore necessary to test the condition of a tube before making an exposure ; we already have seen how the hand may be used, but it is dangerous to expose one's hand frequently for fear of dermatitis. There are other means to measure the degree of penetration.

Equivalent Spark Gap.—If we connect a tube with a coil in the manner shown in the illustration, the discharge will take place through the path which offers least resistance. The resistance between the discharging rods is in proportion to the length of the air gap between them, and can easily be altered. If we put these dischargers so closely together that there is only a distance of about 2 inches between point and plate, the discharge will most likely take place through the air gap only, and the tube will remain dark. If we increase the length of the air gap gradually, a point will be reached when the current suddenly prefers to discharge itself through the tube instead of between the dischargers, and if this point is reached when the dischargers are for instance 4 inches apart, we say that the equivalent spark gap of the tube is 4 inches. A tube is very soft if the equivalent spark gap is 2 inches; soft if it is 3 inches; medium if it is 4 to 6 inches; and hard if it is 7 inches or more.

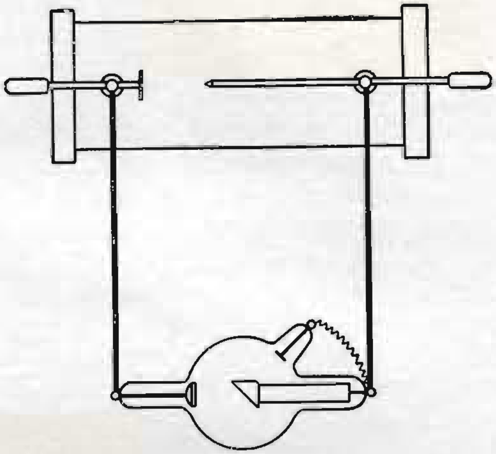


Fig. 7.

The equivalent spark gap is a convenient, but not an accurate or reliable, indication of the condition of the tube; it depends on the amount of current used, on the shape of the electrodes of the dischargers, on the frequency of the interrupter, etc. One and the same tube may have for instance an equivalent spark gap 4·5 centimetres long if measured with a current of 0·3 M.A., but 10·5 centimetres if measured with a current of 1 M.A.

Radiometers.—The penetration can be measured more accurately by means of the radiometers, which were constructed by Benoist, Walter, Wehnelt, and others. Benoist's instrument consists of a thin silver disc surrounded by a circle of aluminium steps of increasing thickness. The only objection to this instrument is that the thickness of the steps increases in arithmetical progression, 2, 4, 6, 8, etc., mm.; the increase is too rapid at the thin end, and too slow at the thick end of the scale. This has been corrected in Wehnelt's modification of the Benoist radiometer; the aluminium wedge used in this instrument increases in a geometrical progression, 1, 2, 4, 8, 16 mm. The transparency of silver is less affected than that of other materials by any change in the penetrating power of the tubes; the luminosity of the field covered by the silver is used, therefore, for comparison, like the light of a standard candle. The radiometers are placed behind a fluorescent screen.

The luminosity of the part of the screen covered by the aluminium changes according to the condition of the tube and the thickness of the aluminium, and if for instance with the tube we are using the aluminium field No. 3 has the

same luminosity as the silver, we say that the tube has a penetrating power equal to No. 3 on the Benoist or the Wehnelt scale, as the case may be.

It is thus possible to obtain an accurate comparison of the degree of penetration of different tubes; and the radiometers enable us to measure it conveniently, and independently of the strength of current used. A comparison of different radiometer units will be found on page 227.

Changes taking place in the Tubes.—While currents are discharging through tubes, changes take place which influence and vary the penetrating power. If the current used is strong enough to heat the anticathode, gases which are embedded in the pores of the metal become liberated, and diminish the degree of exhaustion, and so make the tubes softer. New tubes, in which the metal parts are full of the amount of gases normally contained in the metals, have a great tendency to become softer, and with new tubes prolonged exposures, or short exposures with strong currents, have to be avoided carefully. If serious mistakes are made in this respect, the tubes may become so soft within a few seconds that they show a blue colour, and are useless; such tubes have to be re-exhausted before they can be used again. If an exposure requiring intense X rays has to be made with a new tube, because an old-seasoned one is not available, the only possible way to do it is to use a weak current, and give a long exposure, if possible with a few intervals of rest in between. A strong current would most likely make the tube useless before the required exposure has been given.

After some exposures with moderate currents the tubes gradually become fit to stand stronger currents and longer exposures. They can be "seasoned" to stand strong currents by connecting them repeatedly, at intervals of five minutes or more, for a few seconds with a moderate current, which must not be so strong as to make the tube softer. With some patience tubes can thus be "trained" to stand currents of even 20 M.A. for over 30 seconds at a stretch without suffering harm.

Beginners confuse frequently the meaning of "hard" tubes and "seasoned" tubes, and ask the instrument maker to supply them with "a hard tube suitable to make a good negative of the kidney." Any new tube may be exhausted by the manufacturer so far that it is hard, i.e. gives rays of high penetrating power from the very beginning, but apart from the fact that hard rays are not suitable for making negatives of the kidney, because small stones become transparent and are rendered invisible, the tubes, *while new*, would not keep their hardness for any length of time with either a prolonged exposure or with a short exposure with a heavy current. "*Seasoned*" tubes, on the other hand, whether they are soft, medium, or hard, have acquired the virtue that they can stand either prolonged exposures, or exposures with very strong currents, without liberating at once an excessive amount of gases, and without changing therefore the quality of the rays emitted.

If the anticathode has been raised to a high temperature during or before the process of evacuation, the gases are expelled by the heat, and tubes thus treated have no tendency to become softer even with fairly strong currents. They have the advantage to be more constant at the beginning, but the total

lifetime is sure to be less. The same is the case with old tubes, which have become too hard by use, and have been opened to be re-exhausted ; they have no gases left in the metal of the anticathodes either. But as such tubes are bound to become harder rapidly it is not a wise plan to make the anticathodes incandescent before sealing them into the tubes, and it does not pay to re-exhaust tubes which have been used a good deal already.

Owing to another process, the gases left become gradually less ; some of the electrons are driven into the glass of the tube, others stick to the surface of the glass in consequence of static charges and attractions. This process is a slow one, but it tends to make the vacuum gradually higher and the rays harder, and finally all tubes are bound to become too hard to be of any use. Very weak currents, which do not warm the anticathode perceptibly, therefore make the tubes hard prematurely. Such weak currents are not at all an economy, and do not tend to prolong the life of the tubes, as so many imagine ; but, on the contrary, they are wasteful, as they tend to reduce the lifetime of the tubes, and are to be avoided.

It is an advantage to use tubes with bulbs of fairly large diameter. As the cubic capacity of a tube with an 8-inch bulb is four times as great as that of a 5-inch bulb, the changes which are bound to occur will affect the vacuum of a small tube much more than that of a large one ; and the latter are, for this reason, more constant, and become also less heated.

Normal Current.—The vacuum will remain constant if the quantity of gas which is liberated is as great as the quantity which is being used up, i.e. if the tube is worked with its normal current. A M.A. meter is most convenient to find out whether a tube has its correct load. If the index of the M.A. meter has a tendency to fall, the tube is getting harder, the current used is too weak, and should be increased ; if the M.A. meter has a tendency to rise, the current is too strong for the present condition of the tube, it is becoming softer, and the current should be reduced. If these indications of the M.A. meter are ignored, the vacuum will change, failures owing to wrong penetration and exposure will be frequent, and the lifetime of the tubes will be shortened.

Regeneration.—If a tube is too soft for the purpose for which we require it, it can be made harder, as explained above, by sending quite a weak current through it for some twenty or thirty minutes. If this is not yet sufficient, repeat it after a rest of an hour or more. The process is sure to succeed ultimately, but tubes which are much too soft require, of course, greater perseverance than those in which only a little hardening is wanted. Tubes become harder fairly quickly if the current is allowed to discharge in the wrong direction, either in consequence of wrong connection, or by allowing the reverse current to reach the tubes. This should never be done, for reasons which will be explained under "Reverse Current."

If the tubes are too hard, they can be made softer. If the temperature is raised slightly, by forcing a strong current through them, or by moving a spirit flame under the glass, some of the gases held in the glass-wall become

liberated; but this effect lasts usually only as long as the tube keeps warm: after it has cooled down it is hard again.

All the X-ray tubes of good quality are provided now with some arrangement, which enables us to lower the penetrating power to make the tubes softer. It can be done in different ways.

1. Some tubes have a small palladium tube projecting through the neck of the tube. This metal has the peculiarity that it allows hydrogen to pass through it while red hot, a process which is called osmosis. The palladium tubes are heated with a small spirit flame or a match. The tubes must not be used before the palladium tube has become quite cold again.

2. A quantity of mica, carbon, or similar substances which have the peculiarity of liberating gases when heated, is arranged in a small cylinder sealed to the bulb of the tube, as shown in illustration. In this cylinder the electrodes are fairly close together, and the resistance to the passage of the current is therefore smaller than in the bulb itself. If by means of a projecting wire, which can be raised or lowered, the terminals of this cylinder are brought within an inch or two near the terminals of the tube, sparks discharge, and the

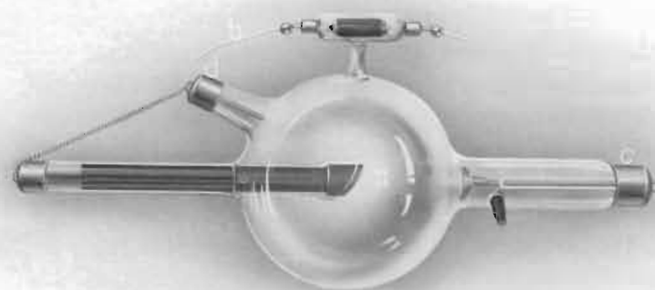


Fig. 8.

current passes through the mica in the cylinder and liberates some gases by heating it. The current used for this process should be weak, and the tube has to be watched carefully, as it will begin to become softer usually within a few seconds.

Or else, the wire from the cylinder may be left during the exposure at a distance of 2 to 3 in. from the terminals of the anticathode; as soon as the resistance of the tube has reached a certain high value, sparks begin to discharge across the air gap, but this ceases when the resistance has been lowered a little. This method is most frequently used, and is called the automatic regulation. This regeneration device acts also as a lightning conductor, protecting the tube against perforation, when it has become so hard that sparks begin to discharge outside.

With the help of a small attachment and an indiarubber tube and ball, it is possible to control and vary the length of the spark gap between the cathode and the wire leading to the mica from a distance, while the tube is working.

3. With a porous material, which allows the passage of air, but is impermeable to mercury, Bauer constructed a valve which allows a small quantity of air to enter from outside. This valve can be fitted to all X-ray tubes. With a rubber bellows and tube, the valve can be opened or closed from a distance while the tube is working, and the effect is watched with a radiometer or the Bauer qualimeter, and the opening repeated till the desired degree of softness has been reached.

Care must be taken not to overdo the regeneration, and it must be well remembered that frequent alteration, especially frequent hardening of a tube, tends to shorten the lifetime of it. It is therefore a bad plan to use one tube only, and to soften or harden it frequently to adapt it to different purposes. It is much more economical in every way to keep several tubes of various degrees of hardness.

REVERSE OR CLOSING CURRENT.

The current which is induced on breaking the primary circuit has the *same* direction as the inducing current ; the current which is induced on closing the primary current has an *opposite* direction, and is called the closing or reverse current. Its existence is a great inconvenience in X-ray practice, and a source of expense. Happily it is bound to be weaker than the current induced on breaking the primary current, for the following reasons :

When the magnetic field appears it induces a current not only in the secondary coil but in the primary coil as well. This current in the primary is called the extra current, or the self-induction, and its strength depends on the intensity of the magnetic field and the number of turns of the primary coil, because the E.M.F.'s induced in the single turns become added, and increase with every additional turn. As the extra current has a direction opposed to the direction of the primary current, it forms an obstacle, and retards its growth ; in closing the primary current some little time is bound to elapse before it can overcome the resistance of the extra current, and the greater the amount or degree of self-induction and the lower the E.M.F. of the primary current, the longer will it take before primary current and magnetism can reach the maximum. Such an obstruction does not exist on breaking the primary circuit, because the current induced has then the same direction ; the break is thus more rapid than the make, and the sparks produced on breaking are therefore always more intense than those induced on making, but under unfavourable circumstances the closing current may reach fully 25 per cent of the E.M.F. of the current induced on breaking the primary circuit.

Professor Walter obtained, for instance, from a coil which gave sparks 23 in. long on breaking the primary current, sparks

	$\frac{3}{4}$	$2\frac{1}{2}$	$5\frac{1}{2}$ in. long
with	37	110	220 volts

on closing the primary circuit. The same number of ampères was used in all cases. The E.M.F of the currents induced by closing the primary current *rises in direct proportion with the E.M.F.* used in the primary circuit, and *in inverse proportion with the self-induction of the primary coil.* Though it is impossible to prevent the creation of reverse current entirely, we can influence its strength considerably; to keep the intensity of the closing current low, the E.M.F. used in the primary circuit should be low and the self-induction, i.e. the size of the iron core and the number of turns of wire on it should be great.

The frequency of the interruptions has also a decided influence on the amount of reverse current. X-ray tubes are not conductors in the ordinary sense: they are insulators until the E.M.F. has reached such a high value that the insulation is broken down and a discharge takes place. The gases become heated to a high degree, and while in this condition they conduct comparatively well, and their resistance is low. If the current is closed again very soon after the break, before the heated passage caused by the previous discharge becomes dispersed, a lower E.M.F. can discharge which would find the resistance too high if more time had elapsed between the make and break. With frequencies of 80 to 150 per second more reverse current is invariably present than when the frequency is only 20 to 40, and unnecessarily high frequencies should therefore be avoided. One and the same tube is harder when used with a low frequency, than when used with a high one. The spark discharges look very imposing with high frequencies, but the negatives are better and the tubes last longer with low frequencies of the interrupter.

If the E.M.F. of the reverse current is sufficiently high to overcome the resistance of the tube, a current discharges in the wrong direction, some irregular rings and patchy spots appear on the glass wall of the whole tube and the fluorescence shows some milkiness and some violet light in the part behind the anticathode which ought to remain dark. There is no sharp division any more between the luminous and the dark half. A very sensitive indicator of reverse current are the—

Oscilloscope Tubes.—Two aluminium wires, separated only by a small gap, are enclosed in an evacuated glass tube, and the wire connected with the negative pole becomes surrounded by a purple fluorescence. If the current discharges in one direction, one of these wires only shows the violet light. But if each wire is alternately + or − pole, both become fluorescent, and the length of the fluorescent band indicates the intensity of the current; so that we can also compare the relative strength of the closing and the breaking currents. Fig. 11 shows the appearance of the oscilloscope tube with plenty of reverse current, Fig. 10 with very little reverse current.

Fig. 9.—Oscilloscope Tube.

Deterioration of Tubes through Reverse Current.—If a current is allowed to discharge through a tube in the wrong direction for any length of time, the platinum of the anticathode becomes disintegrated, and is deposited as a fine grey dust on the walls of the glass. It is generally supposed that this platinum dust combines with the remaining gases, thus making the tubes harder. At any rate, long practical experience has proved beyond doubt that tubes through which current is allowed to discharge in the wrong direction become unreliable, inconstant, hard, and useless much sooner than those tubes which are protected against reverse currents. In the latter case the tubes assume gradually a pretty violet or amethyst colour, whereas in the former case they become smoky grey.

The reverse current interferes also with the reading of the M.A. meter and makes a correct measurement impossible; this will be explained later on under "M.A. METERS." Finally, the majority of the—

Secondary Rays are produced by the reverse current. The cathode rays start from the anticathode or anode, they strike the glass wall of the tube

Fig. 10.

Fig. 11

and are converted there into X rays. All those X rays which do not emanate from the focus of the anticathode are called secondary rays. They have the same penetrating power as the primary rays, and are especially plentiful in hard tubes. They project the outlines of the objects in other directions than the primary rays do, and on account of this the sharpness of the outlines and the contrasts of the picture are reduced, some fogginess is caused in which fine details, which would be so valuable in more difficult cases, get lost. Some secondary rays are also started, or else diffusion of the primary rays takes place, in the thicker parts of the patient's body.

The X rays *a a* (Fig. 12), emanating from the focus of the anticathode, project a shadow B B of the object O on the plate. If there were no secondary rays, this shadow would be of uniform darkness from B to B, and the space B C D would be free from any shadow. But if any current discharges in the wrong

direction, the so-called secondary rays are generated on the glass bulb; they are indicated by the dotted lines *b b*. Although weaker in intensity, they project nevertheless shadows of the object, and in another direction than the primary rays will do; the shadows overlap, and the part between A B will not be as dark as that between A A, and the space between B C will not be as clear as that between C D. The effect of the secondary rays is therefore to make the outlines less sharp, and to cause a general fogginess. In consequence of this, some details will become indistinct and the finer ones will disappear entirely.

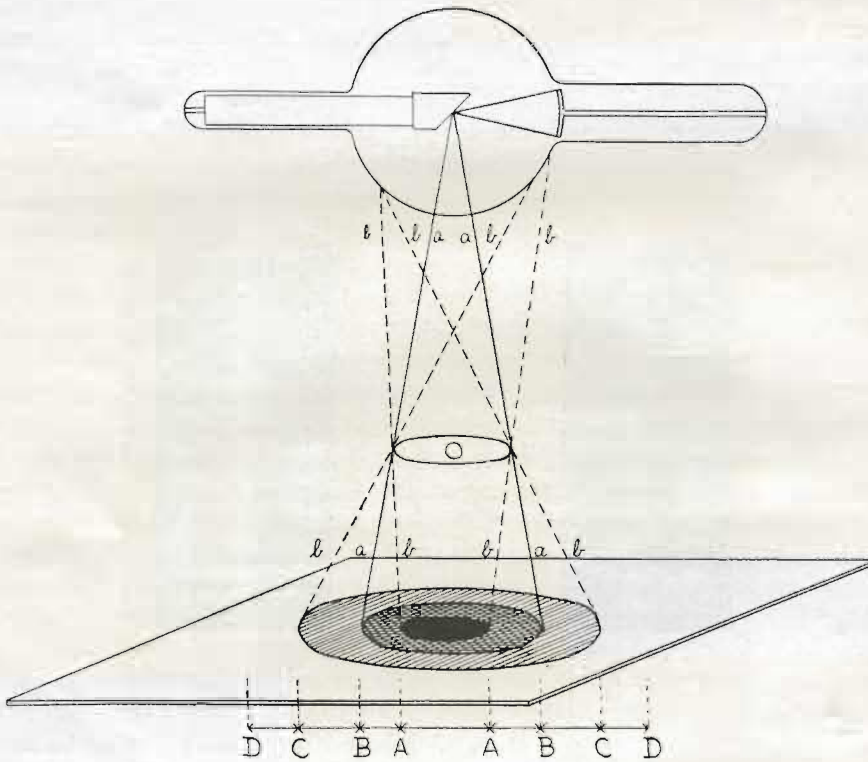


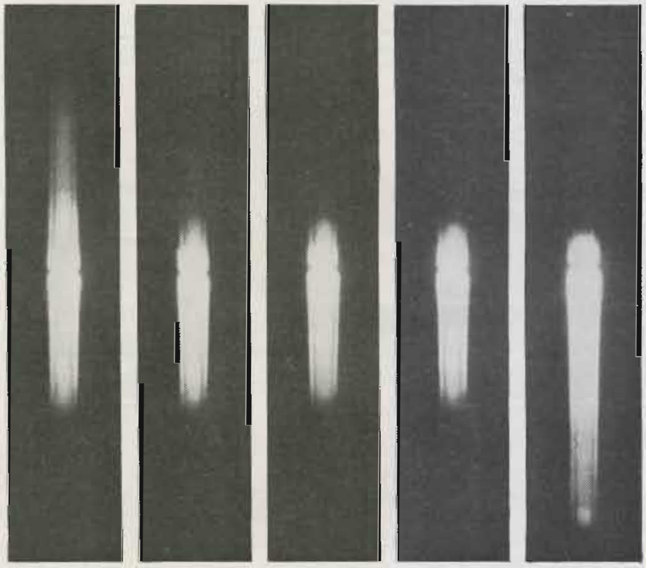
Fig. 12.

The reverse current is therefore a great inconvenience in every way. It causes waste of the usefulness and lifetime of the tubes, makes the dosage by means of the convenient M.A. meters inaccurate, and starts the secondary rays which cause fogginess in the negative, and loss of fine details. We try, therefore, to reduce or suppress the reverse current as far as possible. On page 194 it has already been explained that by using a low voltage, a high self-induction, and a low frequency in the primary coil, the intensity of the reverse current will be kept low; but if intense discharges are used, we cannot suppress it entirely in this way, and other means are available to minimise its ill effects.

Valve Tubes or **Spark Gaps** are frequently connected in series with the X-ray tubes. In a spark gap the current can discharge easily between a point and a plate if the point is the + pole, but it does not do so if the point becomes the − pole. It is thus possible to create an impediment or high resistance to the current in *one direction only*, whereas the passage is left free in the other. There are various types of valve tubes ; I have compared several of them ; the appearance of the oscilloscope tube proves that there is no difference in the rectifying effect and the resistance of the three types examined.

The first picture (Fig. 13, A) shows the appearance of the oscilloscope tube, while the X-ray tube was used alone without any valve tube in the circuit.

B shows the effect of a Gundelach valve tube.
C shows the effect of a Sir Oliver Lodge valve tube.
D shows the effect of a Villard valve tube.
E Villard tube, with coil in shunt, high self-induction.



A B C D E

Fig. 13.

It will be seen that there is no difference in the rectifying power of the three valve tubes which have been compared. None suppresses the reverse current entirely under the conditions, which were arranged *intentionally*, so that plenty of reverse current should be produced. But if the closing current is limited, by using a lower voltage and a higher self-induction in the primary, the proportion of the closing current to the breaking current will be much smaller, and even with double the number of M.A. passing through

the X-ray tube, any of the three valve tubes will suppress the closing current under such conditions almost completely, as shown in Fig. 13 E.

Valve tubes or spark gaps should always be in the circuit if *new* or *soft* tubes, or if very strong currents are being used, or if the tubes are to be used for a very long time. Many X-ray tubes are also so constructed that the reverse current finds some obstruction.

If a fairly low voltage, a high self-induction, and a moderate frequency of the interrupter are being used in the primary circuit, and a valve tube in the secondary, it is possible to reduce the reverse current with a weak or moderate discharge to nil, and to obtain sharp division between the luminous and the dark half in the X-ray tube. If strong currents are being used for instantaneous exposures, we are compelled to use a fairly high voltage in the primary, and in such cases some reverse current may be present in spite of

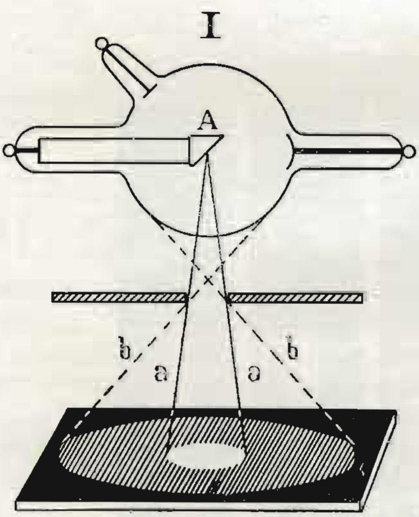


Fig. 14

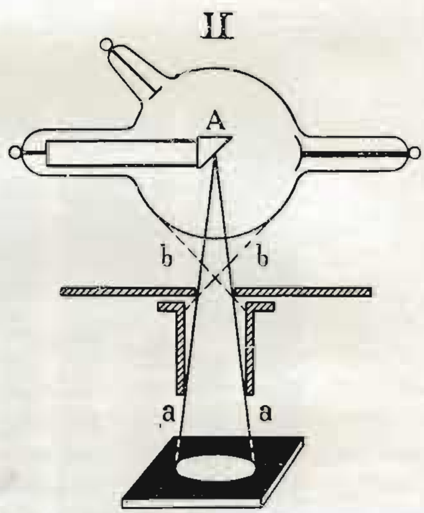


Fig. 15

the precautions mentioned above. To prevent it deteriorating the quality of the negative—

Diaphragms are used. The illustration (Fig. 14) shows the primary or principal rays *a a* emanating from the anticathode A; the dotted lines *b b* indicate secondary rays emanating from the glass wall of the tube. If we place a diaphragm between tube and plate, some of these secondary rays are stopped, and the nearer the diaphragm to the tube, and the narrower its aperture, the more efficient will it be. But as metal plates cannot be brought quite close to the tube, some secondary rays will still reach the plate unless a *cylinder diaphragm* is employed, as suggested by Dr. Albers Schoenberg. Fig. 15 shows why a cylinder diaphragm is bound to exclude more secondary rays than a flat diaphragm can do; the cylinder diaphragm can be used with advantage also for compression, which is a great help, and will be explained later on.

The importance of the diaphragms is equally great whether negatives are to be made or whether the patients are examined on a fluorescent screen, and it is rather surprising that some Hospitals and Surgeons continue to ignore their advantage. All those who have only once had the opportunity of comparing, for instance, the appearance of a heart with and without a diaphragm, will agree with me. Some details, like small foreign bodies, calcifications, small tubercular lesions, cracks in the bones, etc., cannot be discovered at all without a diaphragm, whereas they appear clear with one. I was present once at a demonstration where the patient was known to have a few gunshot pellets in the chest, but nobody could see them, not even the expert specialist giving the demonstration. He doubted their presence, and I was at last allowed, by way of experiment, to place a diaphragm before the tube. The pellets then appeared quite clear to everybody present, but disappeared again when the diaphragm was withdrawn.

MEASURING THE X RAYS. DOSAGE.

A correct dosage of the X-rays is obviously most important, but it is the part which gives most difficulties to beginners. We cannot measure X-rays as easily and accurately as we can measure heat or electric currents, but there are methods which, when properly used, enable us to determine the quantity applied with sufficient accuracy to avoid any risk of injury through over-exposure, or failure through under-exposure.

There are a **direct and an indirect method.**

With the **direct method** we watch the change which the X-rays produce in the colour of certain chemicals like barium platino-cyanide, bromide of silver, etc. We have learned by experience that the quantity of X-rays which will make the hairs fall out, or which will produce a slight inflammation of the skin, an erythema, produces also a certain definite change in the colour of these chemicals, and by exposing them while the patient is being exposed, and comparing them from time to time with the colour of standard tints, this change in colour can be utilized to indicate when the dose of X-rays has been reached which will cause an erythema to appear two or three weeks later, or when one-half or one-quarter of that dose has been given.

Holzknecht was the first to suggest this method, but his original pastilles were unsatisfactory. Sabouraud and Noire then recommended the use of small discs of barium platino-cyanide, the same material which is used for fluorescent screens. They are green when new, but the dose which produces erythema changes them to a red-brown colour. Sabouraud gives only this one tint for comparison. Bordier and Holzknecht use similar pastilles, but have provided several intermediate tints to correspond to one-half, or one-quarter, etc., of an erythema dose. These platinum pastilles are affected not only by X-rays, but by heat and light as well, the distance between them and the glass wall of the tubes should therefore not be less than 2 cm., and they must be protected from light. They have to be compared with the standard tints soon after the exposure, as the discoloration goes back gradually to the original green, at any rate after the first or second exposure. The

comparison should be made in a light which is weak in actinic rays; Sabouraud recommends a weak daylight, Holzknecht and Bordier the light of an incandescent lamp.

Kienböck introduced bromide of silver paper. It is more sensitive, and the range in colour between the white of the unexposed paper and the very dark grey of the colour produced by the erythema dose is so great, that nine intermediate tints of various shades of grey are provided on the standard scale. Kienböck calls these degrees x. 10 x produce an erythema and are equal to the Teinte B of Sabouraud, 5 x are one-half, 2 x one-fifth, etc. This greater sensitiveness and range of colour are certainly an advantage, and the tints are permanent and can be kept as a record; but, on the other hand, the silver paper strips have to be developed for one minute in a developer of standard strength, and if a permanent record is desired, they have to be fixed and washed like photographic prints.

These Chromo-Radiometers are simple, but unfortunately their usefulness is limited to the therapeutic applications of X-rays. They are of no use when negatives have to be made, because they are not sensitive enough. A good negative of the heart of an adult requires only $\frac{1}{100}$ part of the quantity of X-rays necessary to produce an erythema.

The **indirect method** helps us out of this difficulty. For this, suitable **Milliamperemeters** are necessary. They do not measure X-rays at all, they only register the strength of the current passing through the tube; but nevertheless, when properly used, they have proved so convenient and reliable that they are considered now to be indispensable in all X-ray installations. If their readings are supplemented by the *penetrating power* of the tube, we have an indication of the intensity or the actinic power of the X-rays generated in the tube, and if we measure the *length of time* for which the X-rays are allowed to act, and the *distance* existing between tube and object, we can judge the quantity, or dosage, which reaches the object. After experience with thousands of exposures, tables have been compiled (see pages 227 and 229) which give: (1) The number of milliampère seconds which should be used to obtain good negatives of the various parts of the body, from teeth, fingers, the heart, or the head to the pelvis or stones in the bladder or kidney; (2) The penetrating power which should be used; and (3) The best distance. Other tables show the number of milliampère seconds which, with the penetrating power and distance mentioned in the tables, will cause an erythema to appear, or certain effects on skin diseases, the ovaries, etc. These tables have been corroborated over and over again, by many authorities, and by repeating exposures under the same conditions the *same results will always be obtained again*. It thus becomes possible for beginners to profit by the experience gained previously, and to avoid the failures due to under-exposure and the dangers and risks following over-exposure.

It is obvious that the effects produced by the X-rays must vary with the length of time they are allowed to act, and with the distance existing between the tube and the object. Figures about this latter will be found on pages 204 and 227.

The influence of the *penetrating power* is more difficult to understand, and at first sight puzzling. With the distance remaining the same, 100 milliampère seconds will produce the same degree of density on a plate only as long as the penetrating power of the tube used remains the same. With a softer tube, a larger number of milliampère seconds are necessary to reach a certain effect than with a hard tube. In other words, with the same number of milliampère seconds, *the quantity of X-rays obtained in a given time from a hard tube is greater than that obtained from a soft tube.* The rays from the harder tube have a greater intensity, or actinic power. It has been found that with a tube of a penetrating power equal to No. 5 on the Wehnelt scale, just about twice as many milliampère minutes have to be given to reach tint B on a Sabouraud pastille or to produce an erythema, as will be necessary with a tube of No. 8 on the Wehnelt scale (see also the tables on page 228).

The explanation for this is not very far to seek. With a dynamo, the total candle power it can give depends not on the ampères alone, but on the product of volt × ampères, and with X-rays it is the same. The intensity of the rays generated in the tube is in proportion to the number of milliampères × volt used. As hard tubes have a higher resistance than soft ones, more volts are necessary to force a current of say 2 milliampères through a hard tube than through a soft one. The higher voltage propels the electrons with a greater velocity, and this is the cause of the greater penetrating power of the rays from hard tubes.

If a voltmeter were available to measure the E.M.F. of these intermittent currents of high voltage, it would be much simpler, but unfortunately there is none up to now, but as the penetrating power increases in the same ratio as the resistance of the tubes and the voltage to overcome it increase, the penetrating power, which can be measured (see pages 188, and 227), can be substituted for the unknown voltage. But we must not only ascertain the penetrating power before beginning the exposure, we must also watch whether it remains constant or increases or diminishes during the exposure, and the milliampèremeter is the most convenient and sensitive indicator for this purpose too, as will be explained at the end of this chapter.

There is yet another matter which has to be considered to prevent errors with this method. If reverse current is present, the indications of the milliampèremeter become inaccurate. Milliampèremeters of the d'Arsonval type cannot be used for measuring alternating currents; if the two phases have an even strength, one tends to pull the index to the right, the other to the left, and the result is that it remains at zero. If the phases have an uneven strength, as may be the case in X-ray practice, the milliampèremeter indicates the *difference* between the two phases, but it does not indicate the full strength of the preponderating phase. This is therefore another reason why the reverse current has to be carefully suppressed. I have mentioned before that with currents of weak or medium strength, which are most frequently used, modern coils give practically no reverse current, but if either very strong currents are used to obtain short exposures, or if the coil is old, or if the exposures have to last a long time for therapeutic applications, it is necessary

to remember that reverse current may cause the milliampèremeter to indicate too little. An oscilloscope tube in the circuit will show the absence or presence of reverse current, and its intensity.

The milliampèremeters do not even register the actual strength of the current, but indicate only a mean of the strength of the single discharges, and the number of discharges in unit time; fifty *intense* discharges per second may produce the same number of milliampères as 100 discharges of *half the intensity*, because the position of the index depends on the parallelogram of forces, but it is a decided *advantage* that this is so. If they were to indicate the maximum of each single discharge, without regard to frequency, as for instance oscilloscope tubes do, it would be necessary to measure the product of the number of milliampères by the number of discharges used. This would be an additional complication with some interrupters, and would be almost impossible with others, for instance, the electrolytic interrupters. As they indicate only the mean value, we have only to measure the product of the number of milliampères by the time used. The milliampère seconds have the same value whether the current was produced with a large or a small coil, with a mercury or an electrolytic interrupter, but they have another, lower value if the current has been produced by the transformation of the waves of alternating currents. This is more fully explained on page 183. Milliampèremeters of the hot-wire type cannot, however, be used for X-ray purposes.

When the use of milliampèremeters was proposed for X-ray work, these matters, especially the great influence of the penetrating power, were not fully understood, and the usefulness was disputed. Mistakes are certainly possible, if the penetrating power is not measured correctly or if the presence of reverse current is overlooked, or if distance and time are not measured, but it is universally admitted now that when used properly, the milliampèremeters of the d'Arsonval type are the most reliable and sensitive instruments we have to measure the quantity of X-rays.

The M.A. meters are also very convenient for watching the tube during exposure. If a tube has its proper load, the index of the M.A. meter keeps steady. If more current has been turned on than the tubes will stand for any length of time without changing, the needle rises gradually, and it does so long before even the most experienced operator can notice any change in the colour of the light. If the hint given by the M.A. meter is followed, and the current reduced a little, the tube can be kept constant; if it is disregarded, it will soon become softer, and the exposure may have to be stopped for a little while. On the other hand, if the needle of the M.A. meter shows a tendency to fall, more current is wanted to prevent the tube from becoming harder. There are no other means as reliable, sensitive, and convenient to control the condition of the tubes, and a M.A. meter indicating from 0 to 5, and with a shunt to 50 M.A., is a great convenience, and a saving of tubes and time.

EXPOSURE.

Selecting a Tube.—Before making an exposure, we must select a tube with a suitable degree of penetration for the object of which we wish to obtain a negative. Please remember that the difference in the density of the shadows is due to a difference in the atomic weight of the objects. Between a bone and the surrounding muscles, or between a foreign body like a bullet or a steel

needle and the flesh, there is a great difference in atomic weight, and for this reason fractures, dislocations, and some foreign bodies are easily diagnosed by means of the X rays, and the degree of the penetration of the tube used does not matter so much in such cases, provided that the tube is not so soft that the rays are stopped and absorbed by the surface already and cannot reach the plate at all. But differences between the atomic weight of small stones, calcifications, tumours, tubercular lesions, etc., and the surrounding flesh are very small, and if the tube is only a little too hard, fine details are bound to disappear entirely.

If a *reliable* diagnosis of small stones in the kidney or bladder is wanted, or of small tuberculous lesions, cracks in bones, tumours, etc., a suitable degree of penetration is all important ; if the tube should be a trifle too soft, we can correct the fault by exposing a little longer ; if it is too hard the fine details get lost, because small stones, tumours, etc., become transparent too and disappear. The majority of failures in X-ray negatives is due to the fact that the tubes used were too hard, and that no diaphragms have been employed.

Many surgeons are under the impression that it is sufficient to have one tube only ; if it is wanted chiefly for finding fractures or bullets, it may do, but if wanted for finer work, the vacuum has to be corrected too frequently ; the better way, and the more economical one, is to have three to five tubes : one soft, two or three medium, and one hard. The new tubes are usually soft, and should be used only for thin objects, like hands, etc., requiring a weak current and a short exposure. After they have been used for a number of exposures on such objects, they are advanced a step, and are used for knees, shoulders, lungs, the heart, etc. When they have become medium hard, they are used for the head, spine, and for examination on the screen. After they have become hard, they are regenerated, as described on page 192, or in the directions for use received with the particular tube, and take a lower place again ; although softer, they can now stand fairly strong currents or longer exposures, and are used for exposures for stones in the kidney, etc. If tubes are used in this manner better results will be obtained, less time is wasted, and the bill for tubes will be smaller than when one tube has to do everything, and has to be made harder or softer too frequently.

If there is no tube with a suitable degree of penetration available, the nearest one can be made a trifle softer or harder, as the case may be, in the manner described on page 191. If a tube is only a little too soft, there is no need to correct it, but we have to expose a little longer.

How the degree of penetration can be tested has been already explained under Radiometers, on page 189.

When the tube has been selected, it is suspended in the stand so that the axis of the tube is *parallel* to the plate ; it is a mistake to incline it towards the plate. The wires must be attached to the terminals of the tube securely, that they cannot possibly fall off and come near the patient, that they do not cross one another, and that they do not pass too near the bulb of the tube, as otherwise there would be some risk of perforation. The tubes should be free

from dust or dampness, and should not be placed too near the coil, as otherwise the cathode rays would be deflected by the magnetism of the iron core. The focus would not then be always on the same spot, and the outlines on the negative might become unsharp. The distance should not be less than 5 feet to either end of the iron core. It is also frequently desirable that the patient should see the tube working for a moment before the actual exposure is made, because some of them may be frightened and move when they suddenly see the green light in the tube or hear a little noise for the first time.

The Distance between Anticathode and Plate is important. The intensity of the X rays is in inverse proportion to the square of the distance. If we have to expose 3 seconds for a certain object with a distance of 10 inches between the anticathode and the plate, the time of exposure required with

	10	12	16	20	25	30	40	50	60	80	inches.
will be	3	4·32	7·68	12	18·75	27	48	75	108	192	seconds.

The distance to be chosen depends on the thickness of the object. If the distance is too small, the distortion will be great, as is apparent from *Fig.* 12. To obtain, for instance, the shadow of the heart in natural size, the distance between anticathode and plate ought to be 80 inches. Distances as large as this cannot be chosen unless we have an apparatus capable of giving very intense currents, otherwise the exposure would be too long. When the connections have been made, the current is switched on for a moment, to see that the apparatus is working properly, that the tube is connected correctly, that it gives a steady, intense green light with sharp division between the luminous and the dark half, and to measure approximately the M.A. of the "normal" current (see page 191) which can be used, as this is one of the items which determines the length of the exposure to be given.

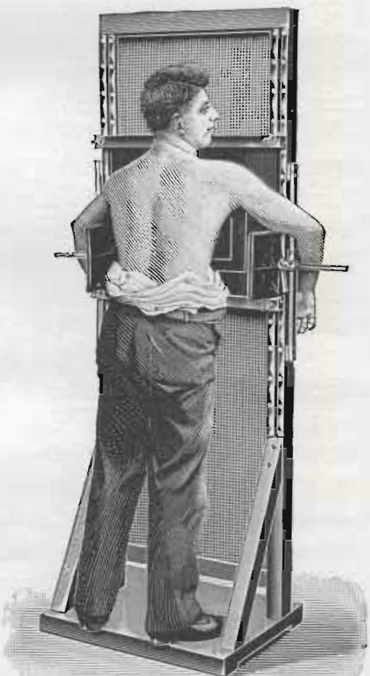
Plates.—The special X-ray plates which are being made now by many manufacturers are decidedly superior to the ordinary portrait or landscape plates, in consequence of a thicker coating of bromide of silver, which makes them more sensitive to X rays, and likely to give more fine details. Ordinary plates are less sensitive, and give fewer details ; they should be used only if it is impossible to obtain the special plates. It is not advisable to keep the films or plates packed in envelopes stored for too long a time, as all materials, except glass, deteriorate the emulsion. The stock of plates must not be kept near the place where the exposures or experiments are being made, unless they are placed in a lead-lined box or "plate safe," as all the plates may be affected and rendered useless.

The plates are placed in suitable cassettes, or red and black envelopes, in the dark room, in such a manner that the rays will reach the sensitive emulsion *without having to pass through the glass of the plate.* Cassettes lined with a sheet of lead at the bottom are decidedly better than only paper envelopes, because the lead efficiently stops any X rays after they have reached the plate, so that no secondary radiation can affect the plate from below, the negatives are less foggy, and are protected against breakage.

The photographic plate has to be adjusted under or above the patient, so that the part to be taken comes in the *centre* of the plate, and the anticathode of the tube should be above (or below) the centre of the plate, so that the principal ray from the focus of the anticathode reaches the object to be taken and then the centre of the plate.

The Patient.—That part of the body which is to be examined should be as near as possible to the plate. If the spine or the kidneys are to be examined, the plate must be on the back of the patient, and the tube in front; if the heart or the front ribs are to be examined, the plate must be on the chest, and the tube behind the back. The part to be examined should be naked to avoid shadows of buttons, clothes, etc.

For examining the heart, stomach, etc., it is desirable that the patients should be standing, and the plates are suspended on an upright stand against which the patient presses; for other parts they may be sitting; for examining kidneys, the spine, a knee, etc., the patients are placed on a couch; but in whatever position they are, they should be *comfortable, so that they can easily keep quiet.* Small pillows or cushions will frequently be a help to keep them quiet in the desired position. If, for instance, the left shoulder has to be taken, a cushion should be placed under the right shoulder, so that the chest is inclined, and the left shoulder as flat and close on the plate as possible.



No. 17.

The œsophagus, stomach, and bowels can be made visible by giving the patient 1 to 1½ ounces of bismuthum carbonicum mixed with porridge, gruel, mashed potatoes, etc. Barium sulphate is now recommended by many authorities. It is cheaper than bismuth. 2¾ oz. may be given by the mouth, in milk gruel, or 10½ oz. may be administered to an adult in a starch enema. Examination to be made immediately after the enema has been given, or 6 and 24 hours after the barium meal has been taken.

The size and position of the stomach appears clearly, tumours, malignant growth, hour-glass stomach, etc., become visible, and the peristaltic movement can be seen on the screen. Later on, the bismuth meal helps to make the position, size, and movement of the bowels visible. The exact time which the food takes to pass through the alimentary tract, or through any part of it, can thus be ascertained. Exposures of the stomach can be finished with the powerful apparatus now available in $\frac{1}{5}$ of a second or less.

If foreign bodies, artificial teeth, coins, etc., have to be shown in the œsophagus, the patient should be placed obliquely so that the shadows are not covered by the shadow of the spine, but appear at the side of it.

Stones in Kidney, Ureter, Bladder, etc.—Large stones were found occasionally with the help of X rays before the year 1900, but great progress in the diagnosis of stones was made only after the cylinder diaphragm with compression was introduced by Prof. Albers Schoenberg in about 1904. The technique has become so improved, that stones weighing as little as $\frac{1}{8}$ of a grain have already been shown clearly on negatives. The secret of success lies :—

1. In the selection of a tube with suitable penetrating power, about No. 7 or $7\frac{1}{2}$ on the Wehnelt scale. Hard tubes are useless for this purpose, because stones may become transparent, and are rendered invisible with hard rays.

2. In excluding the secondary rays by using suitable coils, diaphragms, and valve tubes, if the latter should be necessary.

3. By using suitable compression to reduce the thickness of the patient, and to prevent movement of the kidneys, etc. For this latter reason, the exposure should be finished in such a time that the patient can keep his breath. If the apparatus gives a current of 10 M.A. or more, it is better to dispense with an accelerating screen, but with weak currents it is the lesser evil to use a screen than to risk movements of the objects ; small stones might disappear entirely owing to the excursions due to breathing.

4. The gases in the bowels are transparent and cause dark spots on the negative, which interfere frequently in the region of the bowels. An aperient taken the day before helps somewhat, but a plane convex Luffa sponge pressed into the region of the kidney with the compressor disperses any gas bubbles which may be between the kidneys and the abdomen, and helps to obtain such a clear picture that even the shadow of the lower part of the kidney becomes visible on the negatives, if the patients are not too stout.

5. The plate should be so arranged that part of the spine will appear on it to act as a criterion whether the condition of the tube, the exposure, development, etc., have been correct. The knees of the patient should be raised somewhat to make sure that the spine presses against the plate.

6. Stones consisting of uric acid only cannot be detected with X rays, because their atomic weight is about the same as that of the surrounding tissues. They occur in the bladder, and even large stones, which were clearly visible with the cystoscope, could not be made visible. Stones consisting of pure xanthin or cystin are invisible too, and for this reason it may happen that a stone exists, though a technically perfect negative shows no trace of it. Experience has shown that about 98 per cent of all stones in the kidneys and ureters and 75 per cent of all stones in the bladder will show. All the stones found in kidneys and ureters contain usually some lime too, and this has a greater atomic weight and makes them visible. Stones containing some oxalate or phosphates are also clearly visible.

7. Phlebolites and some calcifications of glands or the aorta may cause slight shadows which may be mistaken for stones.

8. The ureters are not visible, but to find out whether a stone is in the ureter or outside, a catheter opaque to X rays can be introduced first, and the shadows indicate then the exact position of ureter and stone. Tumours, cysts,

and tuberculous diseases of the kidneys cannot be recognised with X rays. If the bladder has to be shown, it may be filled with a 10 per cent solution of carbonate of bismuth, but it is tedious to wash this out afterwards. A 5 per cent of kollargol seems to be better for this purpose, though it does not give a shadow as dense as bismuth does.

Stones of the gall-bladder are very difficult to trace with X rays. They become visible only if they contain lime too, and even then the deep shadow

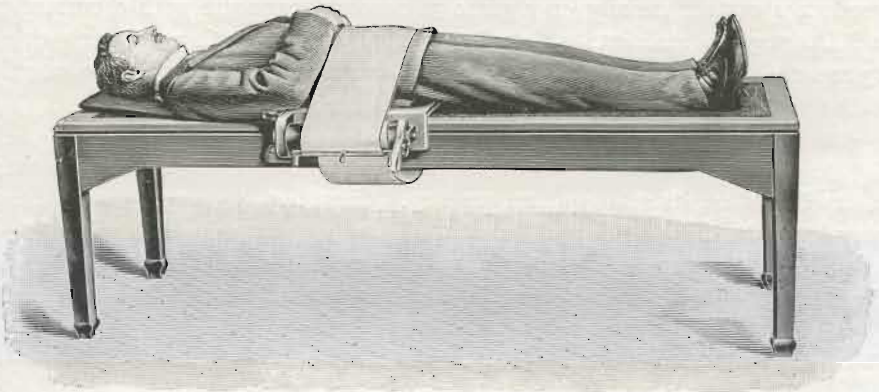


Fig. 18.

of the liver interferes. Large stones in the gall-bladder may possibly be shown by giving the patient an effervescent powder, and placing him on his left side, so that the gases rise towards the pylorus. There is then a little more chance to obtain some contrast between the stones and the surrounding parts.

Compression. — In many cases it will be a help to fix the parts to be exposed either with a broad strap or binder (Fig. 18), which can be made tight with clamps, or with weights, or a few small sacks filled with sand. A cylinder diaphragm, described on page 198, can very well be used as a compressor. In making exposures of the kidneys, this is a great advantage, as it helps to reduce the thickness of the body, but it is useful for many other parts too, as it prevents movement of the patient, and excludes the secondary rays. An inflated rubber cushion can also be used for compressing the abdomen, as shown in Fig. 19.

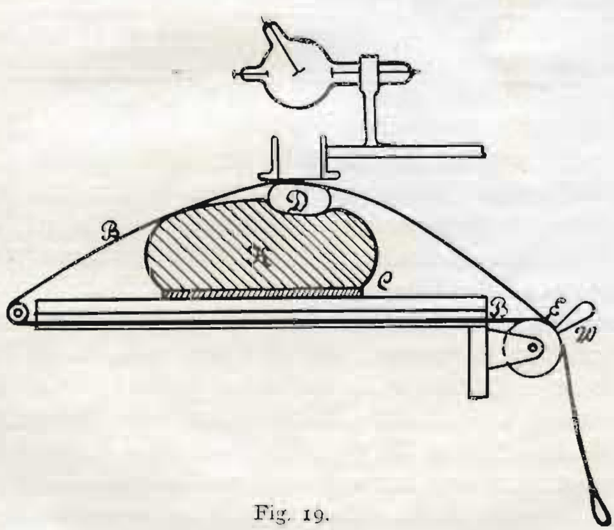


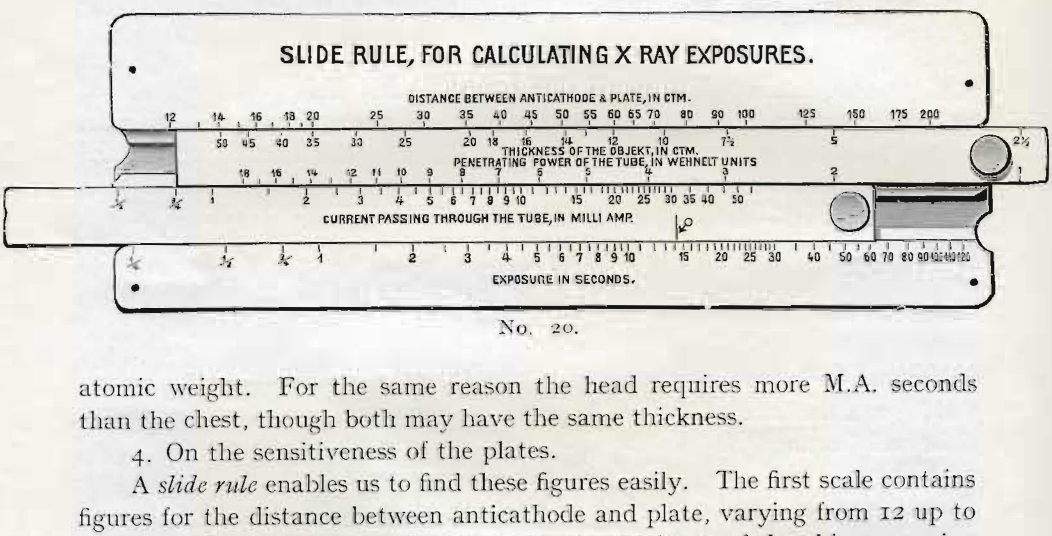
Fig. 19.

The necessary **Duration of an Exposure** depends on :—

1. *The Intensity of the X Rays*, and this is in proportion to the penetrating power of the tube × the number of M.A. used. With one and the same tube, 1 M.A. for 60 seconds, or 2 M.A. for 30 seconds, or 10 M.A. for 6 seconds will produce the same effect on a plate. If tubes of different penetrating power are used, the number of M.A. seconds required with a soft tube may be three to five times as great as that required with a hard one. To produce a certain density on a plate 30 seconds' exposure with a current of 2 M.A. may be sufficient with a hard tube, whereas with a soft one either 150 seconds may have to be given with a current of 2 M.A., or else 30 seconds with a current of 10 M.A.

2. On the *distance* between anticathode and plate, see page 227.

3. On the *thickness* of the object (a knee requires a longer exposure than a hand) and on its relative transparency. Chest and abdomen, for instance, may have the same thickness, but if the latter requires 200 M.A. seconds, 50 to 80 M.A. seconds may be enough for the former, because the chest contains the lungs filled with air, whereas the contents of the abdomen have a greater



No. 20.

atomic weight. For the same reason the head requires more M.A. seconds than the chest, though both may have the same thickness.

4. On the sensitiveness of the plates.

A *slide rule* enables us to find these figures easily. The first scale contains figures for the distance between anticathode and plate, varying from 12 up to 200 ctm. On the second scale, figures for the thickness of the object, varying from 2½ up to 50 ctm., will be found. On the third scale is the penetrating power of the tube in Wehnelt units, from 2 up to 18 ; and the fourth scale contains the figures for the M.A. used, and rises from 0·5 up to 50 M.A.

By adjusting the two slides so that the figures for the distance, thickness, penetration, and current which are being used, are opposite to one another, the index on the second slide points to the number of seconds required for the exposure, which is on the fifth scale, beginning with ¼ and rising up to 120 seconds.

As it may be of value to some readers, I give a table on page 229 showing the average time of exposure required to obtain fully exposed negatives of

different parts of the body. It has been mentioned before that, other things like distance, penetration, and thickness of the object being equal, the duration of the exposure depends on the number of milliampères used. For a shoulder, for instance, of a normal adult, 90 M.A. seconds are required with a tube whose penetrating power is equal to 9 degrees on the Wehnelt scale. If the apparatus and tube allow us to use a current of—

10 M.A.,	the exposure will have to last	9 seconds.
8 ,,	,, ,,	11 to 12 ,,
5 ,,	,, ,,	18 ,,
3 ,,	,, ,,	30 ,,
1 ,,	,, ,,	90 ,,

It is best at first to attempt time exposures with moderate currents. When they have been mastered, and if the apparatus available gives the currents required for rapid or instantaneous exposures (from 50 to several 100 M.A.), the latter will not be found difficult, but they should not be attempted at the beginning.

Instantaneous Exposures have been made as early as 1896 by Dr. Macintyre, and later on by Rieder and others, and since 1908 they have become practical for everyday use. The advantage of very short exposures is, that the movements due to respiration and to the pulsation of the heart and the arteries do not interfere with the sharpness of the image. Other advantages are the saving of time and the greater convenience to the patient. The acceleration of exposure is due to the fact that coils and interrupters have been so far improved that over twenty times more current can be obtained now than was the case up to about 1906. The powerful currents can be reached with 100 to 250 volts and up to 40 ampères, and either with electrolytic breaks, or else with mercury interrupters and a new type of coils specially adapted for them. Good negatives of the heart of an adult can then be obtained with exposures down to about the $\frac{1}{10}$th part of a second, and with the best of these coils and a special mercury interrupter, *one single flash,* lasting about the $\frac{1}{200}$th part of a second, is sufficient to produce X rays intense enough to give good negatives, even of the stomach of a normal adult ; and, of course, of all the thinner parts like the head, heart, etc., too. The pelvis of *stout* adults is, at the time of writing this, the only part which cannot yet be taken with one single flash, but two or three such discharges can be given in rapid succession in about one second, and this is sufficient even in such cases. Besides this, the apparatus can be used with an interrupter in the ordinary way for time exposures of very short duration.

The apparatus which are powerful enough for instantaneous exposures can also be used for tele exposures, i.e., with distances of about 80 inches between tube and plate, to obtain the shadows of objects like the heart, etc., in correct size.

The exact number of M.A. in the tubes cannot be measured with these short exposures, partly because the time is too short, and partly because some

reverse current is frequently present, but the currents generated with the single flash apparatus are sure to reach several 100 M.A.

It is strange that almost all tubes can stand such strong currents for a fraction of a second easily, without suffering harm. Only a part of the heat generated seems to enter the anticathode, whereas with much weaker currents passing for some 30 seconds only, there is greater risk of the tubes turning soft, though the total number of M.A. seconds used must be the same in either case. It is essential for instantaneous exposures that tubes should be used with a fairly thick piece of platinum and a heavy block of metal behind it. Tubes with a thin anticathode, or water-cooled tubes, will not do for this purpose; they would be pierced instantly. A suitable degree of penetration is even more important, if this is possible, with instantaneous than with time exposures; with the latter we can expose a little longer if the tube is somewhat too soft, but with instantaneous exposures such a correction is impossible—if too soft the negative will be under-exposed, and if only a little too hard it will be foggy and the fine details will disappear. The penetration must, therefore, be tested before the exposure is made, and, if necessary, must be corrected, to avoid a failure.

As it is not well possible to close the primary current with an ordinary knife switch, and open it within $\frac{1}{10}$th or $\frac{1}{4}$th of a second afterwards, and as the sparking on these knife switches is excessive, another type of switches is preferable for instantaneous exposures. The automatic switches with horn-shaped contacts enable us to open the circuit rapidly, and the sparks are much smaller than with ordinary knife switches, and they can also be released automatically by a clockwork, which is started by closing the switch. This clock can be adjusted so that the switch will be released within $\frac{1}{20}$th, $\frac{1}{10}$th, $\frac{1}{5}$th, etc., of a second, up to 10 seconds.

Intensifying Screens.—By the use of the new accelerating or intensifying screens, the exposure can be reduced to $\frac{1}{10}$th or $\frac{1}{20}$th of what would be required without a screen. Their use means, therefore, a great saving in tubes, because the latter have to be switched on only for about $\frac{1}{10}$th the time which would be required without them.

The new screens have been so far improved over the older ones, that grain is practically invisible, and fine details, like the structure of bones, come out quite well. With most negatives it is impossible to detect afterwards whether a screen has been used or not. They are, therefore, of great advantage to the owners of older apparatus, which are not capable of producing the strong currents required for short exposures; but even with the powerful modern apparatus they are a great help, because in some heart, stomach, etc., cases, it is a decided advantage to be able to make an exposure in such a short time, that even the pulsation of the heart and arteries and the peristaltic movement cannot interfere any more with the sharpness of the outlines.

It is important that the fluorescent side of the screen should be in *close* contact with the sensitive side of the plate; if there were any air space between, a blurred patch would be the result. The screen must be kept scrupulously clean, and must be dusted with a camel-hair brush; any dust which may be

left on screen or plate will appear as pinholes on the negative, and any finger marks will also appear. The screens should not be removed from the plates for two or three minutes after the exposure is over, because a bluish phosphorescent image remains on the screen, and continues to act on the plate for a few minutes after the exposure is over. Over-exposure should be avoided, as thin negatives without any contrasts would be the result. When intensifying screens are being used, there is no need for the expensive special X-ray plates. Some rapid portrait or landscape plates are faster with the bluish light produced by these screens.

Tele Exposures are made in order to obtain shadows of the heart, stomach, etc., in natural size. As some organs of the body cannot be brought quite close to the plate, they are bound to appear enlarged, the reasons for this being apparent from *Fig.* 12 on page 196. The greater the distance between object and plate, and the smaller the distance between tube and object, the greater will be the distortion. A normal heart, for instance, may appear on the negative fully 40 mm. larger than it really is if the distance between tube and plate is only 25 inches, whereas it cannot appear more than 2 mm. larger than actual size when the distance used was 80 inches.

Since the intensity of the rays diminishes as the square of the distance, powerful currents have to be employed to finish an exposure at such a distance in a reasonable time, but the intense X rays mentioned under instantaneous exposures will do well for tele exposures, with a distance of 2 metres between tube and plate. The necessary duration of exposure need not exceed 1 second, and can easily be made with the patient standing.

Stereoscopic X-Ray Exposures.—Negatives or prints show us everything in one plane; we cannot therefore judge of the relative position of the bones in cases of fracture, or in dislocation of the hip, etc., nor the exact distance between the skin and a foreign body. But if we make two negatives of one object, and move the tube through a certain distance between the two exposures (as indicated in *Fig.* 21), we can examine all the details in stereoscopic relief, and this is a great help in many cases. No complicated apparatus are required to make stereoscopic exposures.

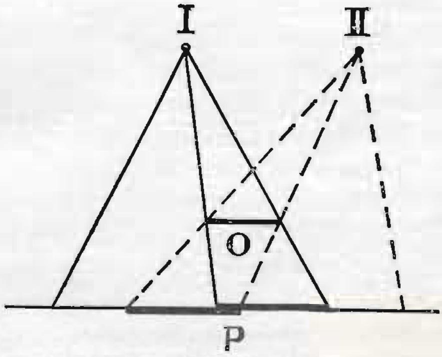


Fig. 21.

It is necessary *that the first plate can be withdrawn after exposure and a fresh plate put in its place without disturbing the position of the patient, which must remain the same for both exposures.* Special cassettes enable us to do this.

The distance through which the tube is to be shifted depends on the thickness of the object and on the distance between tube and skin ; if the object is thick, or the distance small, we have to shift the tube only a little ; if the object is thin, or distance great, we have to move the tube a greater distance. A table giving the distance through which the tube is to be shifted will be found on page 229.

The tube-holders are provided with a scale ; the tube is first fixed so that the anticathode is above the centre of the object to be taken, and the position is noted ; if the tube has to be shifted 6 ctm. altogether, we move it first 3 ctm. to one side of its original position, and after the first plate has been exposed, we move it to a distance of 3 ctm. on the other side, and when the plate has been changed make the second exposure. The plane in which the tube is to be moved must be parallel to the plane of the plate, so that the distance between the anticathode and the plate is the same in both instances The direction in which the tube is being moved must be rectangular to the longest side of the object ; if we take an elbow, for instance, the tube must be moved across, not parallel with, the arm.

Large plates are examined in stereoscopes with reflecting mirrors, or else reductions of the plate can be examined in ordinary stereoscopes.

EXAMINATION ON THE SCREEN.

The part to be examined must be between tube and screen, as near to the tube as this can safely be done without being exposed to sparks, and the fluorescent screen is held close to the other side of the part to be examined. A diaphragm, with a fairly narrow aperture, should be used between tube and patient, as more details become visible, and the contrasts increase, if the secondary rays are prevented from reaching the screen too. It is convenient if tube, diaphragm, and screen are suspended in a frame in such a manner that they can easily be moved up and down together. The greenish light of the fluorescent screens seems to affect the eyes unfavourably, and we cannot detect as many fine details on the screen as on a good negative ; partly for these reasons, and partly to obtain a permanent record, a negative has to be taken in all the more difficult cases. The screens are very good for watching the peristaltic movement of the stomach after a bismuth meal has been given.

Examination on the screen should be made at night time or in a dark room, and only after the operator's pupils have become well dilated. Unless this is the case, no details will be visible. The so-called fluoroscopes, allowing the screen to be used in daylight, are all right to show the bones of a hand at a conversazione, or for testing the condition of a tube, but are almost useless for anything else.

PROTECTION FROM X RAYS.

Some years after the X rays had been discovered, severe burns and several sad deaths after much suffering taught us that these rays produce dangerous inflammations, and later on it was proved that they may cause also sterility. It has to be remembered that all the serious cases were contracted at a time when nobody suspected the dangerous nature of the rays ; the victims exposed themselves at demonstrations, which had frequently to be given while the discovery was new, for hours quite close to the tubes. No sensible person would dream of doing such a thing now, but precautions have certainly to be taken by all those who come frequently in the neighbourhood of tubes.

The first rule is : Whenever possible, do not stand in front of the luminous part of the tube, but keep behind it. By following this rule, many specialists have avoided any ill-effects, though they have employed X rays daily for many years. But it is not always possible to do it ; for instance, in examining a patient with the fluorescent screen, the operator is exposed to the rays too. Whenever a fluorescent screen is used frequently, it ought to be covered with a sheet of lead glass, to protect the face and eyes, and the frame of the screen ought to be provided with metal shields for the hands, or else the operator ought to wear X-ray-proof gloves. The backs of the hands are either the most exposed, or the most susceptible parts, and for this reason the hands ought not to be used too frequently for testing the penetrating power of a tube. People handling dangerous appliances daily are apt to become careless, and the operators and assistants in an X-ray department of a hospital, therefore, require special protection.

An excellent plan is to enclose the tube completely in a box lined with a rubber impregnated with oxide of lead. It does not conduct electricity, and is opaque to the X rays, so that neither X rays nor the green light of the tube can reach the room ; and operator, nurses, and patient are thoroughly protected, without having to wear aprons, spectacles, gloves, etc. These boxes can be fitted on tube stands, compressors, couches, etc., and all kinds of flat diaphragms, cylinder diaphragms, lead-glass tubes, pastille holders, tripods for treating ringworm, etc., can easily be attached to these boxes.

Boxes enclosing the luminous half only of the tubes are quite sufficient as far as protection is concerned, and have the advantage that we can watch the tube. With boxes which are closed entirely all round we cannot watch the tube, but they prevent the green light from illuminating the room, and are for this reason somewhat better for screen examination.

A kind of cabinet has been suggested, in which the switchboard, etc., is to be placed, so that the operator must be there to control the current. These cabinets can be lined with sheet lead, and lead glass, and if properly made give thorough protection to the operator as long as he is inside ; but surely nurses and patients are entitled to protection too, and partly for this reason, and partly to have a diaphragm, the tubes should be enclosed in an X-ray-proof box as described above. If this is properly done the expensive cabinets

are superfluous in the great majority of cases. They may be desirable in a few large hospitals, where several X-ray tubes are being used constantly during the greater part of the day.

It is desirable for another reason that that part of a tube which looks towards the patient should be enclosed in a box. If it were unprotected, there is some slight risk that while adjusting tube or patient, especially while working in a dark room, for examination, a rash movement on the part of the operator or patient, a sudden jerk on the cords, might smash a tube, and glass splinters might become dangerous if the explosion took place near the head. But if the part of the tube near the patient is surrounded by a box, the risk of breakage is much smaller, and the diaphragm would stop glass splinters.

If an examination of chest or abdomen is likely to last some time, it is desirable that the testicles of boys should be protected by a piece of rubber impregnated with oxide of lead.

Patients should not be exposed too frequently on one day. *Patients should also be asked whether they have been already examined or treated recently with X rays by somebody else.*

To obtain a good negative of a stone in the kidney, a larger dose of X rays is required than for a negative of any other part of the body. According to the table on page 230, 250 M.A. seconds = 4 M.A. minutes, are sufficient, with a distance of about 20 inches between tube and plate, if the tube has a penetrating power of 7·5 degrees on the Wehnelt scale. To produce an erythema, 75 M.A. minutes are necessary according to the table given on page 229, with a distance of 16 inches only and a tube of similar hardness. With a distance of 20 inches this would be increased to about 112 M.A. minutes.

The dose required to produce an erythema is therefore about 28 times as great as the dose required for making a negative of a stone in the kidney, and the same patient could be exposed 25 times for a stone in the kidney before an erythema will appear.

DEVELOPMENT.

All the care and trouble and expense bestowed on correct exposure may be wasted unless the development is carried out with intelligent skill, so that all the details which may be in a plate are really brought out. The contrasts are frequently very slight, and may disappear entirely by careless development.

It is easy to control the development in the case of hands, feet, arms, etc., because the picture can be seen fairly well by holding the plate against the ruby lamp, but it requires more experience to develop a thorax or pelvis. In these cases the picture is visible only at the beginning, and it is difficult to know when to stop. The development has to be continued in most cases till the plate looks fairly grey if examined from behind.

The name of the developer is less important than the fact that the operator understands it thoroughly. In consequence of the great thickness of the emulsion it takes several minutes before the developer can penetrate to the deeper parts near the glass; the rapid developers, which have frequently a tendency to cause chemical fog, are therefore unsuitable. It is also generally admitted that it is more difficult, or even impossible, to bring out the finest details with the rapid developers as well as they can be brought out with *slow* development; it happens occasionally that 15 to 25 minutes may have to be spent in developing a negative of a pelvis.

Of the older developers, hydroquinone has an advantage because it gives the greatest density, and soft or hard negatives can be obtained at will by diluting it with water or by adding bromide of potassium. It is very susceptible to the addition of bromide, whereas other developers, like rodinal, are scarcely affected by it, and cannot therefore be modified as much. Unfortunately, hydroquinone has the disadvantage of being very sensitive to changes in temperature; it cannot be used very well in winter, unless the dark room, as well as dishes and solutions, have been warmed. Of the modern developers, glycin is strongly recommended by many X-ray workers. It is less sensitive to changes in temperature, and has the advantage of giving the *clearest* negatives and most details. Development can be prolonged very much with glycin without producing fog.

Glycin is also the most suitable developer for the so-called tank development, which offers great advantages for our purposes if it is not important to examine a plate at once.

Place the plate in a clean tank, in an upright position, cover it with glycin developer, to which 20 times the usual quantity of water has been added, cover the tank with a lid to exclude the light, and leave the plates in for about an hour, and then examine them. All the details which can possibly be brought out will then be visible, and there is no danger that the plates will be too dense; on the contrary, they will frequently be too thin. In this way it is easier to bring out all the details which are in a plate; the most beautiful or perfect negatives which it is possible to obtain can be got with the tank development; it is the best method of bringing as much as possible out of a rather under-exposed plate, and as no long experience is required, it can be left to assistants who are not yet experts in photography without fear that good plates will be spoiled by unsuitable development.

Intensification.—Many X-ray negatives will be thin and wanting in contrasts. If there are details, however faint, such plates can be greatly improved by subsequent intensification. It is quite an easy process, which can be carried out in daylight. The intensification does not only increase the density, it considerably alters the character of the plate by increasing the contrasts and making the picture harder. If, however, the details are wanting on account of under-exposure or unsuitable development, subsequent intensification cannot bring them out, and will be of no help. If the plates are to be intensified, it is very important that they have been *thoroughly fixed and washed*, otherwise stains might be produced.

As most medical men have experience in photography, it is not necessary to give lengthy instructions as to the development, printing, etc., here ; they can be found in the numerous books on photography.

Examining the Plates.—If negatives are compared carefully with prints, it will be seen that some of the finest details are invariably lost by the process of printing on paper. The plates ought to be examined directly. This can be done either by placing them against a window covered with a ground glass, or better still the plates are examined by artificial light in a dark room. Two to four incandescent lamps are placed in a box behind a thin porcelain plate, and the negatives are placed in front of this plate. It is desirable to have a rheostat to control the amount of light, because *thin* negatives show to best advantage with a *weak* light behind, whereas for dense negatives a strong light is necessary.

EXPOSURES FOR THERAPEUTIC PURPOSES.

It has been the custom for some time to recommend for therapeutic purposes soft tubes, and to use them as close as possible to the skin. This is a mistake, unless the action of the rays is desired on the surface only. In the large majority of cases, in treating eczema, lupus, rodent ulcer, etc., with X rays, it is necessary that the rays should penetrate to deeper parts, and the success depends in many cases on whether sufficiently strong doses can be applied to the deeper-seated parts without burning the skin and causing painful inflammations. For this reason it is necessary to select a medium hard tube, because the rays have then a much greater penetrating power, and the percentage of the rays which will be stopped and absorbed by the skin will be smaller. As the intensity of the rays diminishes rapidly with the distance, it is necessary to have the tube 10 inches or more away to prevent too great a difference between the distance of the skin and the deeper parts. The skin can also be protected somewhat by covering it with a leather ; this will act as a filter by stopping the softest rays. Sheets of aluminium 1 to 5 mm. thick are very good filters for obtaining a particular quality of X rays. It has also been found that X rays affect those parts most in which metabolism is active ; if it is reduced, for instance, by pressure sufficiently intense to make the parts anæmic, larger doses can be applied without undue risk for the skin. In some cases the direction of the rays may be changed, so that for part of the dose the tube is in front, for another part behind, or at a right angle, so that the whole dose for a deeper part need not pass through the same piece of skin.

It is desirable to use the tubes always at the same distance ; it will thus be easier to judge the doses given, than when another distance is used each time. Partly for this reason, and partly because protection of the parts not to be treated is absolutely necessary in all these cases, the tubes for therapeutic treatment should be suspended in boxes or diaphragms, enclosing the luminous part, and at the lower end of these diaphragms lead-glass tubes of various

diameters can be attached, which press against the parts to be treated. Protection and a uniform distance are thus maintained.

For therapeutic purposes a *correct dosage* is of more importance than when making negatives. In the latter case the exposure can be repeated if a mistake has been made, but an overdose in therapeutic application may have serious results to the patient, and under-exposure means waste of time, and usually complete failure, or even a stimulation of a growth, etc., instead of the desired destruction !

The dosage depends on :—

1. The penetrating power of the tube × the number of M.A. used.
2. The distance between the anticathode and the skin.
3. The time for which the X rays are applied.

The first can be measured with the help of a radiometer (Wehnelt, Benoist) and a milliampèremeter. The table (*see* page 228) made by Prof. Walter may be found useful. It holds good under the condition that the X rays reach the skin fairly perpendicularly, that the anticathode is of platinum, that there is no filter between tube and skin, and that the thickness of the glass of the tube is 0·6 mm.

Like Sabouraud's pastilles or Kienboeck's quantimeter, this method does not take into account any idiosyncrasy for X rays, if such a thing exists at all.

The dose of X rays which causes within two or three weeks a slight inflammation of the skin, possibly bronzing of the skin, and depilation, is now called the "Erythema dose," or the normal dose.

The Quantimeters, M.A. meters, and Dosage have been explained already on pages 199–203.

After these general remarks about exposures for therapeutic purposes, I will add some detailed instructions about *the use of X Rays in Gynæcology*, which is sure to be used largely in the near future, and *Treating Ringworm with X Rays*, a method of treatment of which the great advantages are already generally admitted. As I have no personal experience in treating patients, I have used the most interesting papers which appeared in the *Lancet*, *British Medical Journal*, and other periodicals, and in various books devoted to these subjects.

THE USE OF X RAYS IN GYNÆCOLOGY.

Albers Schoenberg found, in 1903, that men who were exposed much to X rays were rendered sterile, though the libido sexualis et potentia cœundi remain unimpaired. Experiments conducted on animals proved that the testicles as well as the ovaries shrink and degenerate after having been exposed to a certain dose of X rays, and four to six weeks afterwards no sperma or ova can be found.

Since 1904, attempts have been made to utilize this as a means for **accelerating artificially the advent of the menopause.** The method has already been used successfully in over a thousand cases ; it has been found that the severe hæmorrhage which compels thousands of women to lead the life of invalids for several years, can be cured by the skilful application of the X rays, **without any surgical operation.** Myomata and fibroids shrink, and there is no doubt that a large number of patients, though refusing a serious operation, will be found willing to undergo this treatment, which, without causing pain, or even interfering with their daily occupations, soon restores them to normal health and enjoyment of life.

The *Lancet* of Oct. 28th, 1911, in reviewing a book, "The Roentgen Rays in Gynæcology," by Dr. M. Fraenkel, says :—

"The use of X rays in Gynæcology is rapidly becoming of considerable importance, and it appears that the time is not far distant when their employment will become more general in this branch of medicine than it is at the present day, and when the question of their routine employment in, for instance, the treatment of fibroid tumours, will become a question for gynæcologists to come to some definite decision upon."

Dr. Amand Routh said in his Presidential Address to the Obstetrical Society on Oct. 5th, 1911 :—

"We are at the beginning of a period when other methods of treatment than surgery are gradually being opened up ; but are we not rather closing our eyes to those aids which are already known to us ? How many of us have tried to arrest hæmorrhage from fibromyomatous uteri in cases refusing, or unsuited for, an abdominal operation, by transferring the patient to our electrical colleagues for exposure to X rays ? I have done so, in both hospital and private cases, especially at menopause ages, with distinct success."—(*Lancet*, Oct. 14th, 1911).

DOSAGE OF X RAYS IN GYNÆCOLOGY.

The following is an abstract from the articles written about this subject by Drs. Albers Schoenberg, Bordier, Fraenkel, Gauss, and others.

A correct diagnosis is all important. It would be a grave mistake to apply the X rays in cases of deep-seated malignant growth.

The exact dose required for either a temporary or a permanent sterilization of the ovaries is not known, as we cannot measure the dose which actually reaches the ovaries. The dose required is also bound to vary. In patients of forty-five years and more, the artificial menopause is produced with a comparatively small dose of X rays, because the vitality of the ovaries is already on the decline, but patients below forty years of age require a much stronger dose to reach the same effect. Again, in thin patients the thickness of the tissues between ovaries and skin is only 3 ctm., whereas in stout patients it may be three times as much, and in the latter cases the losses of X rays due to the greater distance between the anticathode and the ovaries, and

the absorption by the tissues, are greater, and more milliampère minutes have therefore to be given with a stout patient than with a thin one.

This may seem too vague at first sight, but the experience gained in the treatment of over 1000 cases helps to overcome the difficulties. The rules to be observed are :—

1. Use a tube with a penetrating power equal to 10 units on the Wehnelt scale. It may have even 11 or 12, but should **on no account** have less than 9 units, and 9 only in the case of thin patients.

Careful attention has to be paid to this, and the condition of the tube has to be watched during the exposure, because if the penetrating power should fall below the degree mentioned, **no X rays will reach the ovaries,** as they would be absorbed by the superficial tissues, and the danger of an erythema will arise if the treatment be continued with a soft tube.

2. As even hard tubes emit a certain percentage of soft rays, it is an advantage to use a suitable filter—leather, or a sheet of aluminium—between the tube and the skin of the patient.

3. The distance between the anticathode and the skin should not be less than 8 in., and not more than 18 in.

4. The position of the tube should be chosen so that for one application it is above the centre of the lower part of the abdomen, for the next sitting it is placed so that the rays enter through the right side, and for the third sitting so that they enter through the left side ; so that on their way to the ovaries they do **not always traverse the same part of the skin.**

5. Too weak a dose should be avoided, especially with very anæmic patients, as it may increase the hæmorrhage temporarily, by irritating the organs without paralysing their functions. A dose of say 6 x in *one* sitting has a more destructive effect than if the same total dose were divided into three equal parts and applied with a few days interval between each sitting, because the organs have a tendency to recover.

6. Three applications of 5 to 6 minutes duration each, with a current of 2 to 6 M.A. should be given on consecutive days. A fortnight's rest should then be given, to watch for any sign of inflammation. If the skin remains quite pale, a similar series of sittings may be given in the two months following, and the treatment is then interrupted for a few months to watch the results.

7. The treatment should be begun as soon as possible after a menstrual period. It should not be begun in the fortnight preceding a period, as this would most likely cause an increased hæmorrhage.

If these rules and precautions are followed, the result is certain in suitable cases, without any danger or risk to the patient.

For those who have not yet a long experience in X-ray dosage, some further explanations may be welcome.

How the penetrating power of tubes can be measured has been described on page 189. Tubes which are near 12 Wehnelt units are already so hard that sparks begin to discharge freely outside ; it is therefore impossible to use harder tubes, and it is not desirable either, because the ovaries would then retain and

absorb too small a percentage of the X rays, and the physiological effects are in proportion to the quantities of X rays which have been absorbed.

Most tubes have a great tendency to become softer if a current of a few M.A. strength is passing through them for any length of time; it is therefore necessary to watch them carefully during the exposure. A M.A. meter is useful for this purpose. If the index of the M.A. meter tends to rise, it is a sure sign that the tube is becoming softer; if it falls, the tube is becoming harder. A convenient new instrument to test the degree of hardness of a tube is also Bauer's qualimeter. It is a static voltmeter, and has to be connected with the — pole, i.e., the cathode of the tube. As long as the tube has a hardness equal to No. 10 on the Wehnelt scale, the index of the qualimeter will point to 7 or 8 on the scale of the instrument.

Should the penetrating power go down, the exposure has to be interrupted, because X rays from a soft tube cannot reach to the ovaries any more: they are absorbed by the skin. The time would not only be wasted, but the risk of erythema, or even dermatitis, would arise if the treatment were continued with a tube of less than 10 or 9 Wehnelt units. The exposure has either to be stopped to give the tube time to cool down, or if the tube has become rather soft, it has to be exchanged for a harder one. On page 191 we have explained how the tubes can be hardened by sending a very weak current through them; but this process takes time, and is not advisable while a patient is on the couch.

Tubes with a good cooling arrangement (water-cooled tubes, or tubes with rib cooling, etc.), and well-seasoned old tubes, will stand the strain of the exposure for a longer time, without becoming soft, than either new tubes or tubes with a less perfect cooling arrangement of the anticathode.

If this kind of treatment is to be applied frequently, in hospitals, or by specialists, it will be worth while to employ a special therapeutic interrupter. It does not replace, but is used in addition to, the ordinary interrupter, and has been constructed to help to maintain the correct degree of hardness. It switches the primary current off and on about 100 times per minute, to give the tubes short rests at frequent regular intervals to cool down. All tubes stand **short** impulses of even very strong currents much better than long-continued though weak currents. Even moderate currents, used for a minute without a pause, have a tendency to make many tubes softer.

As even hard tubes give a certain percentage of soft rays, which are absorbed by the skin before reaching the deeper lying organs, it is an advantage to place a filter between skin and tube to absorb these rays before they can reach the skin. Several layers of chamois leather, of together 4 mm. thickness, are recommended by some, but sheets of aluminium 2 to 5 mm. thick seem to be preferable. They have the peculiarity that they absorb **all** the soft rays and the greater part of the rays of medium hardness, whereas the hard rays pass aluminium filters with scarcely any loss. Aluminium filters should be "earthed," i.e., should be connected by means of a wire with a gas or water pipe, so that if any small spark occurs from the tube to the aluminium, the patient **will** not be hurt by it.

Compression to make the skin anæmic is also a means to render the skin less sensitive to the X rays.

As to the distance between anticathode and skin, if it is too short, the difference in the dose which reaches the skin and the more distant ovaries will be too great ; on the other hand, if the distance is too great, the X rays have to be applied for a much longer time, as the intensity of the X rays diminishes as the square of the distance. It is therefore unadvisable to choose the distance smaller than 8 in. or larger than 18 in.

The luminous part of the tube must be enclosed in a box lined with X-ray-proof material, so that the other parts of the patient and the operator are protected.

Erythema should never happen, and can be avoided if the condition of the tube is carefully watched, the precautions with filters are taken, and the dose is not exceeded. With a tube of 10 Wehnelt units, an aluminium filter of 3 mm. thickness, a distance of 8 in. between anticathode and skin, an erythema dose will be reached in 50 milliampère minutes, i.e., with a current of 2 M.A. in 25 minutes, or of 3 M.A. in 17 minutes. Although the experience of many cases has proved that with a given degree of hardness and distance the erythema dose can be calculated by the number of M.A. minutes applied, it is nevertheless advisable to use as a control some quantimeter method, because the consequences of an over-exposure given by error or mistake are too serious. The discoloration produced by X rays on certain chemicals is used. Either Kienboeck's quantimeter strips, or else Bordier's pastilles may be used below the filter on the skin of the patient. The former are the more sensitive, and give a greater range of colour, but have to be developed, which takes three minutes. The latter give a smaller difference in the colour, but the result can be seen at once. Kienboeck divides the full erythema dose in 10 equal parts, which he calls x, so that 5 x are half an erythema dose, 2 x are $\frac{1}{5}$th an erythema dose, etc.

Few of the experts who have used this treatment up to now advocate giving a full erythema dose of 10 x in one sitting. Some recommend half a dose, others only a quarter dose in one sitting, giving the remainder on the second or third day ; but no more than $1\frac{1}{2}$ erythema doses should be applied within one month. The skin does recover to a certain extent, and three half erythema doses can be given, with an interval of fourteen days between each application, without producing more than a bronzing of the skin.

If the total dose applied within a fortnight is too weak, the hæmorrhage may be considerably increased instead of being decreased. The explanation given is that the weak dose produces only irritation of the ovaries, without paralysing their functions. This is to be avoided, especially with highly anæmic patients.

It has been proved in many cases that when the ovaries have become paralysed after two or three series of sittings, they recover gradually—especially in patients who are not yet near the menopause—and resume within three to twelve months all their normal functions. Patients who have been kept sterilized for over a year were delivered of healthy children

within a year after the application of the X rays was stopped, so that it is quite possible to sterilize patients temporarily only. This may be a great advantage in some cases, and a result which could not be reached by any surgical operation.

THE TREATMENT OF RINGWORM WITH X RAYS.

X rays are being used since 1904 for the treatment of ringworm. This method has been proved to be so much more efficient, and to have so many advantages in every way over the older methods of treatment, that it is universally employed now, and over ten thousand cases have been successfully treated already in Great Britain and on the Continent. There is even a fair hope that with the X-ray treatment this formerly intractable disease may be stamped out entirely in course of time.

As it may be welcome to some readers, we will give here an extract of some articles which appeared about this subject.

J. M. H. Macleod, M.D., writes in the *Lancet* of May 15th, 1909 :—

The X-ray treatment of ringworm is the most rapid, effective, and painless method of curing the disease. With the older methods of treatment, with parasiticide and irritating applications, extensive cases required an average time of eighteen months for a cure. With X rays the same result may be reached in three or four weeks without causing pain or discomfort to the child, and the average time has been reduced from eighteen months to three months. The pastille can be turned to the standard tint in about fifteen minutes with a tube of 8 to 9 Wehnelt units, and half a M.A. of current, i.e. with $7\frac{1}{2}$ milliampère minutes.

Localizers of the required length and diameter are used, the whole affected area is exposed piecemeal, each area after exposure being accurately covered with thin sheets of lead. After the exposure a 3 per cent salicylic acid and sulphur ointment is rubbed all over the scalp each night, and in the morning a carbolic and glycerine lotion (1 in 8) is applied. On the fourteenth day and during the third week while the hair is falling out the scalp is washed every morning. The exposed area should be completely bald by the twenty-first day, and the child is no longer infectious. The hair begins to grow again six weeks later, and the regrowth is complete in five to six months.

This is the normal course of events. The operation necessitates care in matching the pastilles, and entails a knowledge of the disease to enable the operator to map out the scalp so as to include every diseased hair in the exposure.

The chief causes of failure with this method are : (1) Under-exposure, so that an imperfect defluvium of the hair takes place, and infected hairs are left ;

(2) Omission of a focus of disease in the exposure; and (3) Insufficient thoroughness in the after-treatment, so that infection of unexposed areas takes place as the hairs are falling out.

The localizers should not be too large in diameter, so that the convex portions of the scalp are not too near the tube. The regulation distance must be maintained, and care be taken that no area is exposed by mistake twice.

It is probable that fine fair hair requires a smaller dose to bring it out than coarse dark hair, and the hair of a child of four years may come out more readily than that of a child of twelve, but in Dr. Macleod's experience an imperfect defluvium was invariably the result of an under-exposure, and he therefore gives always a full Sabouraud dose. Severe dermatitis is the result of over-exposure, or reducing the distance between scalp and anticathode to less than 15 ctm.

Cases have occurred in which the regrowth of the hair was delayed, or in which permanent baldness of the exposed area followed. This is doubtless due to over-exposure, and the author has not had such a mishap in 1500 exposures.

No injury to the brain or arrest of development, or nerve symptom suggesting the slightest injury has been proved to have resulted from the treatment properly applied. No sensation is complained of until about the fourteenth day, when the part becomes itchy and feels hot, and a faint erythema may be noted just before the defluvium begins. These symptoms disappear in a few days, and no further sensations are experienced. Sabouraud also states that after having treated 3,000 children he has not seen any case with nervous troubles either passing or permanent, or any arrest of development. Dr. Macleod proves by some experiments that even the thinnest part of the parietal bone, with the scalp over it, protects the brain so far already that at the utmost 20 per cent of the dose which reaches the scalp may reach the surface of the brain of a child.

The exposure of an affected hair to a pastille dose does not kill the ringworm fungus, but simply brings out the hair. The chief disappointments met with have been in the cases in which under-exposures have been given, or where a small affected area was missed out, or where the after-treatment between the exposure and the defluvium was carelessly carried out.

A SIMPLIFIED METHOD OF X-RAY APPLICATION FOR THE CURE OF RINGWORM OF THE SCALP. KIENBOECK'S METHOD.

By H. G. Adamson, M.D., *Lancet*, May 15th, 1909.

Depilation by means of the X rays is now fully established as the most satisfactory method of treatment for ringworm of the scalp. By the introduction of Sabouraud's pastilles as a means of measurement of dosage, in trained hands the dangers of the treatment have disappeared. By Sabouraud and Noire's method with circular localizers 10 to 12 exposures are necessary in

order to X-ray the whole scalp, and reckoning fifteen minutes for each exposure, the time occupied in X-raying the whole scalp is from $3\frac{1}{2}$ to 4 hours. By the method to be described the number of exposures necessary to depilate the whole scalp is reduced to five, so that it is possible to irradiate the whole scalp in $1\frac{1}{2}$ hours.

The essential features are that no cylindrical nor lead foil localizers are used, but that adjacent X-ray applications are made in such a manner that at those parts where overlapping does occur, the incidence of the rays is so oblique, and so much further from the source, that no excessive dose is given.

I have used this 5-exposure method with perfect results, every part of the scalp has received an even radiation, and the hair has fallen out completely without any sign of overlapping margins or areas with non-fallen hairs as evidence of insufficient exposure. There is no sign of erythema ; the re-growth of the hair has been normal over the whole scalp.

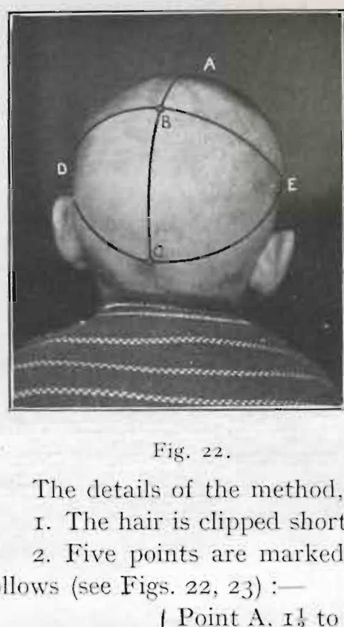


Fig. 22.

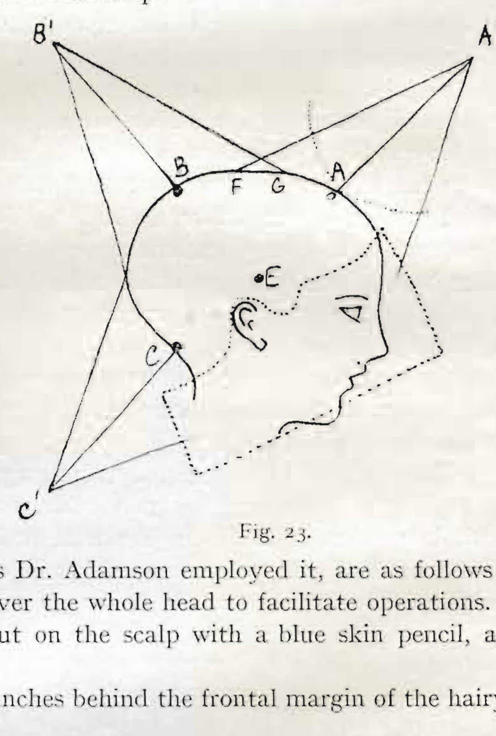


Fig. 23.

The details of the method, as Dr. Adamson employed it, are as follows :

1. The hair is clipped short over the whole head to facilitate operations.

2. Five points are marked out on the scalp with a blue skin pencil, as follows (see Figs. 22, 23) :—

In the middle line.
- Point A, $1\frac{1}{2}$ to 2 inches behind the frontal margin of the hairy scalp.
- Point B, 1 to $1\frac{1}{2}$ inches above the centre of the flat area which forms the upper part of the occiput.
- Point C, just above the lower border of the scalp at the lower part of the occiput.

At the sides of the scalp.
- Point D, on the right side, just above and in front of the ear.
- Point E, on the left side, just above and in front of the ear.

Measured with a tape measure, the distance between any two of the five points should be exactly 5 inches.

3. The five points are joined up by lines made with a skin pencil. These lines should meet one another at right angles. The mapping out of these points and lines need not occupy more than one or two minutes.

4. A Sabouraud pastille dose with the anticathode at 6½ inches from the nearest point of the scalp is given to the vertex, occiput, lower occiput, right side, and left side in succession, taking the points A, B, C, D, and E as the centre of each area to be rayed, and placing the tube so that the line joining the anticathode and the nearest part on the scalp is at right angles to a similar line joining the anticathode with each of the central points of the adjacent areas. The lines which have been drawn on the scalp connecting the five points give an indication of the direction in which the dose is to be aimed—i.e. of the position of the tube in relation to the head. The applications to the vertex, upper occiput, and the two sides are best made with the patient lying on a couch. The forehead and eyes must be shielded by a piece of lead or protective rubber during the exposure to the front of the vertex, and the ears and sides of the face when the sides of the head are exposed. The fifth application, that to the lower occiput, is best given with the patient sitting down and resting the forehead on a low table. A shield must be used to protect the neck.

In order to ensure fixing the anticathode at the correct distance from the scalp during the exposure, three slender wooden pegs are fitted to the box which encloses the tube. The pegs converge at their extremities to within ¼ inch of each other, and are of such a length that the part of the scalp which rests against them is just 6½ inches from the anticathode of the tube. The pegs are made of soft wood, so as not to obstruct the passage of the rays through them. An illustration of this tripod for treating ringworm will be found under No. 2614*c* in the price list. The pegs rest against the scalp just over the blue marks A, B, C, D, and E, according to the area to be rayed. The aperture in the box through which the rays pass is 3 inches in diameter and 3¼ inches from the anticathode, so that at the level of the points of the pegs the rays diverge to a circle of 6 inches diameter, and in this way one avoids the escape of rays into the room or towards the operator or on to the patient's shoulders, for a circle of this diameter is blocked by the patient's head. At the same time this circle of irradiation allows a good margin for the necessary overlapping of the doses.

The essential points in this method are to direct each irradiation *at right angles* to the direction of the irradiation of adjacent areas, and to aim not at a point in the centre of the vertex, of the lower occiput, or of the sides of the scalp, but towards the outer margin of these areas, so that half the dose goes on to the scalp and half on to the shield protecting the face and neck. If these precautions be taken there is no risk of over-exposure at the overlapping margins of the rayed areas. In practice the dosage works out so nicely that every part receives an equal amount, and depilation is total and complete, without anywhere a sign of over- or under-exposure. In theory, according to the well-known laws that the quantity of rays received at any point exposed varies (1) Inversely with the square of the distance from the source; and

(2) Directly with the size of the angle of incidence, the dose received by any part of the scalp is found to be, with mathematical accuracy, one pastille dose.

Other interesting articles on this subject, confirming the great value of the method, the absence of any risk of injury to the brain, and the safety, provided tubes with suitable penetrating power and correct dosage were used, were published by :—

S. E. Dore, M.D., in the *Lancet* of Feb. 18th, 1911, pages 432 to 436, and R. H. Cooper, *Lancet*, Aug. 14th, 1909, pages 467 to 469, and *British Medical Journal*, Aug. 21st, 1909, pages 454 to 456.

Care must be taken that the same child is not exposed twice by mistake. This accident has actually happened in a hospital !

MALIGNANT GROWTHS.

It has been proved beyond doubt that X rays have an influence on malignant growths : a weak dose stimulates and accelerates the growth, a strong dose kills the malignant cells.

In the numerous cases of malignant growths of the skin, good results and permanent cures have been reached in many cases, because doses of sufficient strength can be applied to the skin, but there is no single case on record that a deep-seated malignant growth has been cured yet by X rays. We have not yet learned how to administer a dose of sufficient strength to kill the malignant cells of subcutaneous or deep-seated tumours without destroying the healthy surface too, and causing severe, incurable dermatitis ; but steady progress is being made, so that all hope need not be abandoned. The only good results reached up to now with X rays in cases of deep-seated malignant diseases which are past surgical operation is that pain can be relieved in many cases, and the discharge can be reduced.

Warts disappear, and leave only a flat and soft scar.

Excellent results have been reached in treating *lupus vulgaris* with X rays. Though the rays do not kill the tubercle bacilli themselves, the diseased cells perish, and disappear gradually in consequence of the inflamed condition of the surrounding tissues. Tubercular glands can also be treated successfully with X rays.

EXPOSURE TABLES.

COMPARISON OF DIFFERENT RADIOMETERS.

Benoist	2	$2\frac{1}{2}$	3	4	5	6	7	8	9	10
Benoist-Walter ..	1	2	3	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	—	—
Walter	2–3	3–4	4–5	5–6	6	6–7	7	7–8	—	—
Wehnelt	1·8	3·3	4·9	6·5	7·2	8	9	10·5	13	15
Bauer	1	2	3	4	5	6	7	8	9	10

PENETRATING POWER.

To obtain good negatives of various parts of the body, the tubes should show the following degrees on the Wehnelt Radiometers :—

For teeth, with the film in the mouth	6 to 7
For fingers, hands, nose, or eye	6·5 to 8
Stones in the kidney or bladder	7·5 to 8·5
Arms, knees, shoulder, lungs, heart	8 to 9·5
Spine, head, pelvis	8·5 to 10

For treatment of ringworm, internal organs, ovaries, etc. 10 to 14

For thin and juvenile patients, the lower figures; for stout or elderly ones, or if the exposure has to be very short, the higher figures should be used.

The Intensity of the X rays varies with the Distance between Anticathode and plate or object.—The intensity of the X rays is in inverse proportion to the square of the distance. If we have to expose for a certain object 3 seconds with a distance of 10 inches between the anticathode and the plate, the time of exposure required with

	10	12	16	20	25	30	40	50	60	80 inches.
will be	3	4·32	7·68	12	18·75	27	48	75	108	192 seconds.

or, expressed in other figures :—

Distance	10	14·1	17·3	20	22·4	24·5	26·4	28·3	30 ctm.
Exposure	10	20	30	40	50	60	70	80	90 M.A. seconds.

The distances usually chosen are :—

For teeth, toes, fingers, or hands	10 to 12	inches.
Arms, neck, leg, or foot	12 to 15	,,
Nose, head, shoulder, knee	20 to 22	,,
Chest, kidney, pelvis	22 to 25	,,
For treating ringworm	6 to $6\frac{1}{2}$	,,
,, ,, ovaries, etc...	8 to 18	,,

COMPARISON OF DIFFERENT QUANTIMETER UNITS.

Sabouraud ..	—	—	—	1	—	—	—	—	—
Holzknecht ..	—	3	4	5	6	7–8	10–12	15	20–22
Kienboeck ..	3	6	8	10	12	14–16	20–24	28	40–44
Bordier ..	1	1·8	2·7	3·8	4·7	5·8	8	10	15

SABOURAUD'S PASTILLES.

According to Walter, SABOURAUD'S PASTILLES, exposed at a distance of 13 ctm. from the anticathode, WILL ASSUME THE B TINT IN

	97	48	33	25·7 M.A. minutes.
if the penetration is	3·3	4·9	6·5	8 degrees on Wehnelt scale,

and if the thickness of the glass is 0·4 mm.

ERYTHEMA DOSE.

According to Walter an ERYTHEMA DOSE will be reached in :—

Penetration / Distance between anticathode and skin in ctms.	3·3	4·9	6·5	7·2 Wehnelt Units	
10 ..	20	9·5	6·4	4·6	M.A. minutes
15 ..	44	21·5	14·5	10·4	,,
20 ..	81	38·0	25·5	18·6	,,
25 ..	128	60·0	40	29·0	,,
30 ..	184	86·0	58	41·5	,,
35 ..	250	117	79	57·0	,,
40 ..	328	153	102	74·5	,,

According to Kienboeck, the *erythema dose*, 8 to 10 x, will be reached with a medium hard tube of No. 8 Wehnelt units, and a distance of 20 ctm. between anticathode and skin, with a current of :—

0·2 M.A. in	64–80 minutes.
0·6 ,, ...	21–27 ,,
1·0 ,, ...	13–16 ,,
2·0 ,, ...	7–9 ,,

The figures given by Kienboeck agree with those given by Walter.

STEREOSCOPIC DISTANCES.

For Negatives to be examined in a stereoscope, the distance which the tube has to be shifted between the exposure of the first and the second plate varies with the thickness of the object and the distance of the anticathode from the surface of the object. Marie and Ribaut have given us the following table about this :—

Thickness of the object: Centimetres.	If the distance of the Anticathode from the surface of the object is—			
	20	30	40	50 ctms.
	The Tube has to be shifted			
2	4·4	9·6	16·2	—
4	2·4	5·4	8·8	13·5
6	1·7	3·6	6·1	9·3
8	1·4	2·8	4·1	7·3
10	1·2	2·4	4·0	6·0
15	—	1·8	2·9	4·3
20	—	1·5	2·4	3·5
25	—	1·3	2·1	3·0
30	—	1·2	1·9	2·7

EXPOSURE TABLE.

	Dist.	Penet.	M.A. Seconds
Head, sideways	CD	9	110
Head, occipito-frontal ..	CD	9	160
Head, eye and nose	CD	7·5–8	100
Head, teeth, plate outside ..	CD	7·5–8	100
Head, teeth, film inside ..	16″	7–8	15–20
Cervical vertebræ	CD	8–9	75
Lumbar ,, ...	CD	9	200
Sacrum	CD	9	200
Stones in kidney or bladder ..	CD	7·5	250
Stomach, bowels	24″	9	80
Stomach, with accelerating screen	24″	9	20
Pelvis	24″	9	200
Hip joint	CD	9	150
Chest, ribs	24″	9	80
Sternum	CD	8	120
Heart or lungs	20″	8	60
Heart, Tele-exposure ..	80″	9	120
Shoulder	CD	8	90
Arm	CD	7	30
Hand	20″	7	12
Knee or upper leg	24″	8	75
Lower leg or foot	24″	7	50
Foot	CD	7	35

If you divide the number of M.A. seconds given in the column on the right-hand side by the number of M.A. you are using, you will obtain the number of seconds the exposure should last.

Dist.—The distance given in inches means the distance between anticathode and plate.

C.D.—Cylinder diaphragm. The distance is then composed of (1) The thickness of the part of the body to be taken; (2) The length of the cylinder diaphragm, which is 6 in.; and (3) The distance from the upper edge of the cylinder to the anticathode, which is 3 to 5 in.

Penet.—Penetrating power of the tube, as given in Wehnelt units.

M.A.—Milliampères.

M.A. Seconds.—The time given is for medium-sized adults and a current of 100 volts. With 200 volts the exposures will be somewhat shorter, with accumulators it will be longer.

If a tube turns softer during an exposure, it has to be prolonged, and the current has to be reduced. If a tube turns harder during an exposure, it has to be shortened, and the current increased.

If softer tubes are used the exposure has to be prolonged 40-50 % for every additional degree of softness.

Illustrated Price List

OF

X-RAY APPARATUS.

"X-RAY APPARATUS AND THEIR MANAGEMENT" will be found on pages 175–229.

Estimates and illustrations of **Complete X-ray Outfits, etc.,** will be found pages 292–301.

Practical Instruction in making X-ray Negatives can be given by appointment, to Medical Men only, *in our new X-ray Laboratory at No. 71, New Cavendish Street, London, W.*

A series of **Lectures,** with experiments and practical instruction, are held from time to time. Particulars as to date, etc., can be had on application.

Experts can be sent at moderate charges to any part of Great Britain, to connect apparatus and to give our customers **practical instruction in the use of X-ray Apparatus**.

SPARK COILS.

For X-ray purposes it is of the utmost importance that the strength of current, *i.e.* the number of milliampères which can be reached through the tube should be *as great as possible, the greater it is, the shorter will be the exposures.* More particulars about this will be found on page 178.

As it is of no advantage to have an E.M.F. greater than that which can produce sparks 20 in. long, we have given up building coils for spark lengths exceeding 20 in., and as we consider the customary method of classifying the spark coils by the spark length only to be obsolete and almost meaningless, we add other particulars which are more helpful in coming to a decision as to the size of coil best suited for the purpose for which it is required.

Coil No. 2512 is specially built for dental purposes, for the treatment of ringworm, etc. It is wound for a spark length of 10 in.

Coil No. 2515 is the size of coil most frequently chosen. It is powerful enough for the large majority of cases, and can be used equally well for making first-class negatives of any part of the human body, for examination on the fluorescent screen, and for therapeutic purposes. The distance between the terminals is 12 in., but the coils are wound for a spark length of 16 in. With a mercury interrupter, and on a 220 volt supply, we obtain over 70 M.A. through an air gap 8 in. wide, over 12 M.A. through a medium hard tube, No. 8 Wehnelt scale, and up to 30 M.A. through a tube No. 6 Wehnelt. A Sabouraud pastille exposed at a distance of 15 ctm. from the anticathode will reach tint B in less than 2½ minutes.

This means exposures of 5 seconds (see footnote)* for a fully exposed negative of the heart or lungs of a male adult of normal size, and an exposure of about 25 seconds for a stone in the kidney. With an intensifying screen these figures can be reduced to 0·25 seconds for the heart and $1\frac{1}{2}$ to 2 seconds for a stone. With a Wehnelt interrupter, the duration of exposure can be somewhat reduced also.

Coil No. 2518 can be used for all the purposes mentioned under No. 2515. The distance between the terminals is 17 in., but the coils are wound for 20 in. spark length. The duration of the exposure is about 25 per cent shorter than those obtained with Coil No. 2515, and when used with an intensifying screen the exposure for a stomach of a normal adult can be reduced to about $\frac{1}{10}$th part of a second.

Coil No. 2521 can also be used for all purposes mentioned under No. 2515. The distance between the terminals is 20 in., the primary coil has a diameter of 6 in., a length of 47 in., and the weight of the complete coil is $2\frac{1}{2}$ cwt. With a *special* mercury interrupter, sparks like those illustrated on inset overleaf are obtained with this size coil, and negatives of the heart, lungs, and all the extremities can be obtained with *one single flash*, i.e., in about the $\frac{1}{200}$th part of a second. The pelvis of medium-sized or stout adults is the only part which may require two or three such flashes (which may be given in rapid succession). With the *ordinary* mercury or electrolytic interrupter a good negative of the pelvis of an adult can be reached in 12 to 15 seconds without an accelerating screen, and in about 0·6 seconds with such a screen. This coil can be used, too, for examination on the screen and for therapeutic exposures. It is impossible to state the actual number of milliampères reached with the single flash, the

* We have given the number of seconds required for exposures of the heart and stones, though it is difficult to do this, especially in a price list. There is great latitude in the duration of exposures, they vary with the quality of the negative desired, the age, sex, and size of the patient, the quality of the tube, etc. If details of the structure of a bone are wanted, to find a tumour or a tuberculous disease, we may have to expose six times as long as when only the outlines of the same bone are required to show a fracture. It has become a custom with some writers to publish "record" exposures, which have been reached by straining interrupter and tube to limits which could not be maintained for any length of time, and with exceptionally thin patients. Under such circumstances the times mentioned above can be reduced to less than one-half; but though these very short record exposures are interesting, and useful in some cases, it would be misleading to *beginners* to mention them here, because it is not advisable to repeat them in every-day practice.

To prevent any misunderstanding or disappointment, we should like to add here, too, that although a beginner can reach the strength of current mentioned above quite well, and can obtain a good negative of the heart in 5 seconds, he should not attempt to make a negative of a stone in the kidney in 25 seconds, *unless he has a seasoned tube which will stand currents of* 10 *M.A. for* 25 *seconds*. New tubes will *not* do this. More particulars about these matters will be found on page 190.

Statements that with such-and-such an apparatus such-and-such a fraction of a second will be sufficient for making a negative should not be compared with one another unless the negatives can be made under identical conditions, i.e., with the same tube, current, object, distance, etc. The number of milliampères which can be reached through a tube is meaningless too, unless the exact degree of hardness of the tube is known, and it is not possible to measure this as accurately as, for instance, the temperature can be measured.

To compare the relative efficiency and power of various coils and interrupters, the number of milliampères obtainable through an air gap is more reliable, and before deciding on a particular make, it would be wise to ascertain :—

1. How many milliampères the coil is guaranteed to give through an air gap 8 in. long.
2. How many volts and ampères are required to produce this discharge (see pages 178–179.

exposure is too short to be measurable with the milliampèremeters, but it can be clearly seen that the current through the X-ray tubes exceeds 100 M.A.

In ordering a coil, please mention whether it is to be used with accumulators (20 to 30 volts) or with the current from the main (100 to 250 volts); and whether it is to be used with a mercury or an electrolytic interrupter, to enable us to choose the wire for the primary coil correctly.

IMPROVED SPARK COILS.

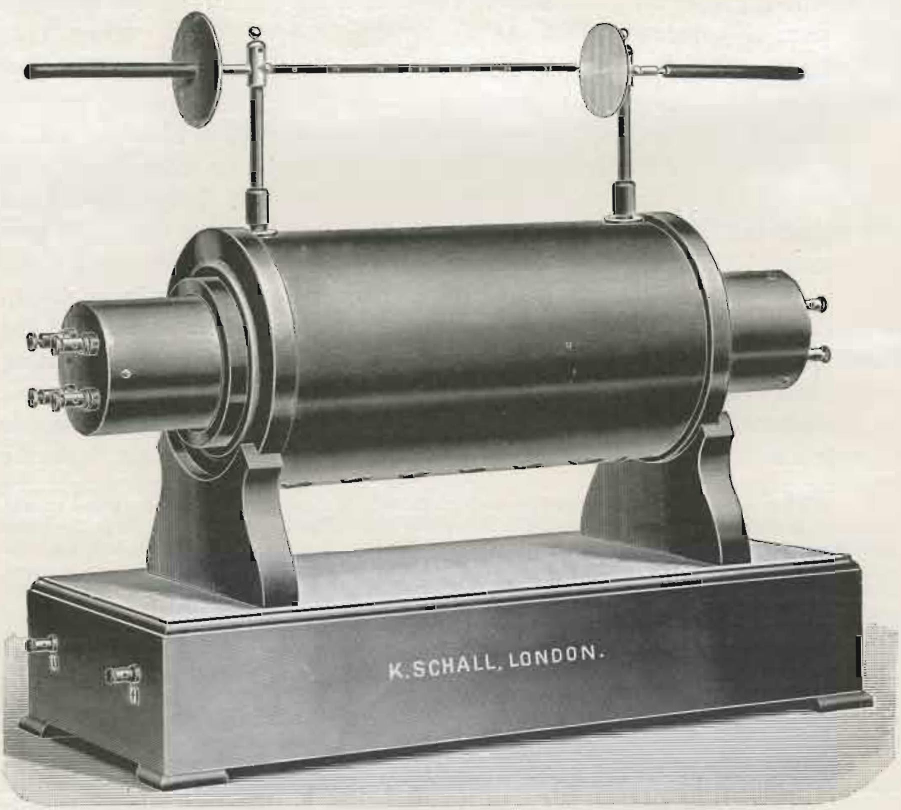
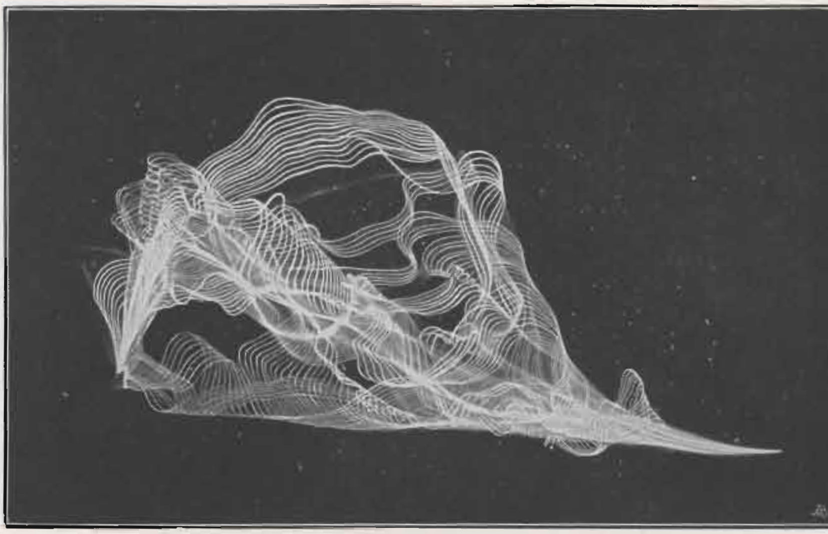
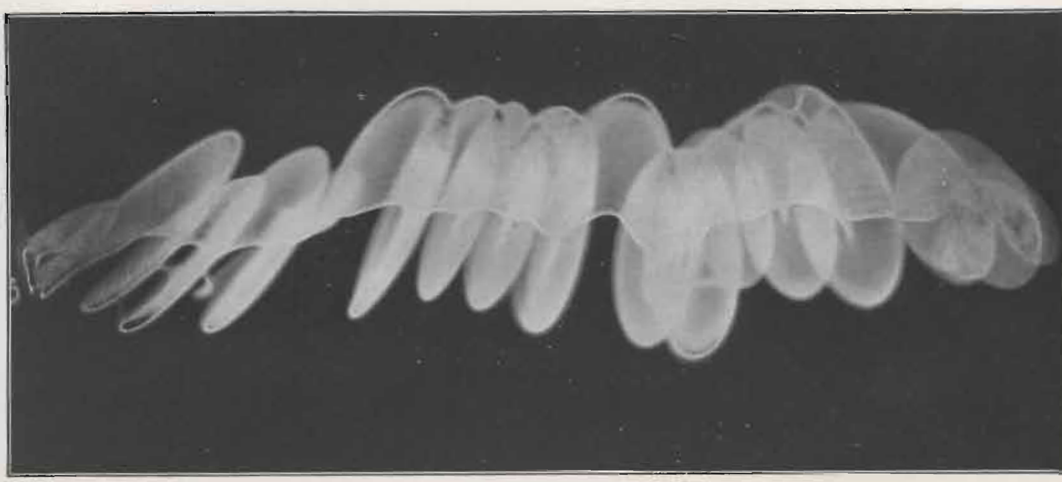


Fig. 2518.

	M For Mercury Interrupters.	E For Electrolytic Interrupters only.	C For Mercury and Electrolytic Interrupters.
No. 2512	£18 10 0	£16 0 0	—
,, 2515	28 0 0	26 0 0	29 0 0
,, 2518	45 10 0	43 0 0	47 0 0
,, 2521	77 0 0	74 0 0	80 0 0

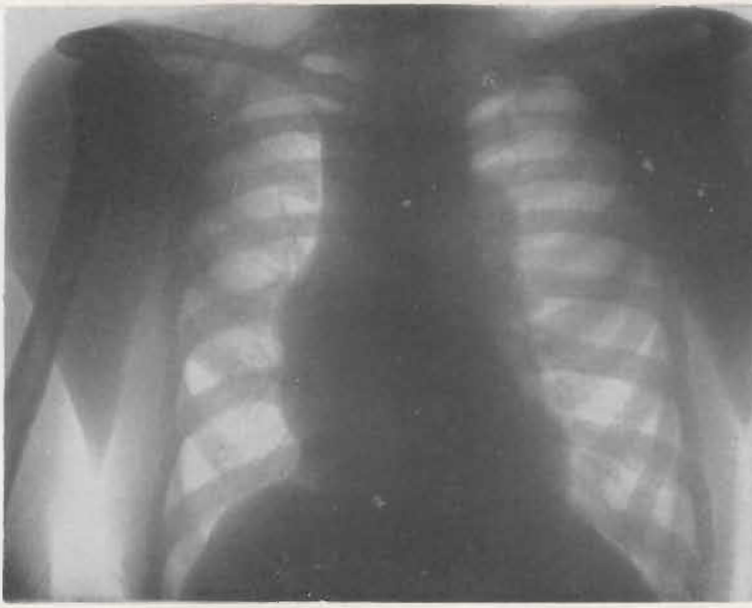


Discharge obtained with an Electrolytic Break.

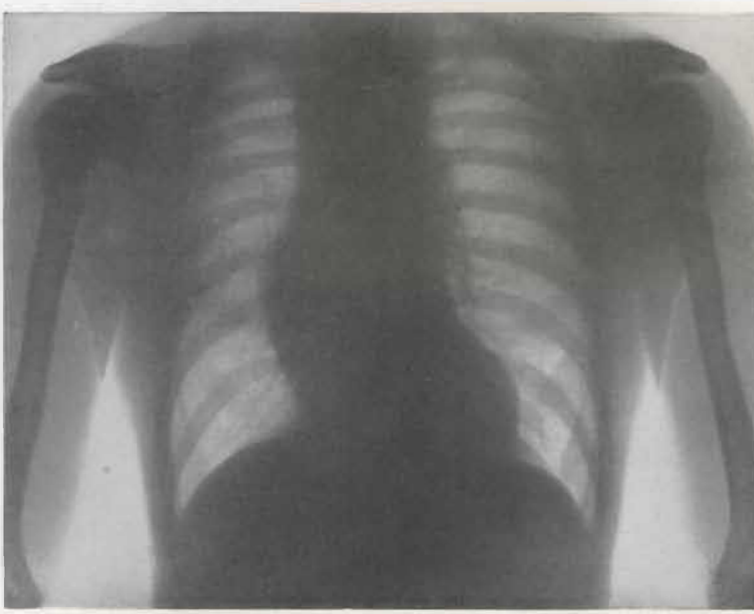


Single sparks obtained with mercury breaks, sufficiently powerful to give good negatives of the stomach of an adult with one single flash (exposure about $\frac{1}{100}$th part of a second).

To face page 232.

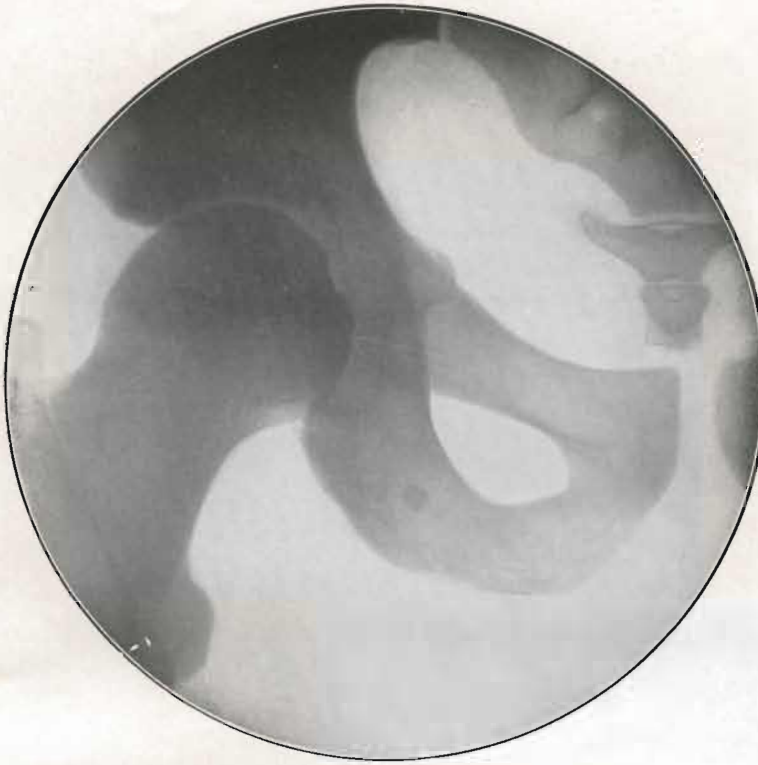


1908. Exposure, $\frac{1}{[illegible]}$th of a second. Distance between tube and plate, 25 inches.



1908. Same patient. Exposure 1 second. Distance between tube and plate, 80 inches.

The two negatives were obtained at a demonstration of instantaneous and tele exposures given at the London Hospital in May, 1908. 200 volts and 55 ampères were available. The two illustrations show the difference in the size of the heart and ribs if taken with a distance of 25 or 80 inches between tube and plate.



1909.

The prices quoted for spark coils *include* divided spark gap.

Spark coils mounted on cabinets, trolleys, etc., and portable coils will be found under Complete X-ray Outfits on pages 292–301.

The coils M, for mercury interrupters, are provided with a condenser.

The coils E, for electrolytic interrupter only, are without a condenser, but are provided with variable self-induction.

The coils C, for mercury and for electrolytic interrupters, are provided with condenser and with variable self-induction. The latter is indispensable for electrolytic interrupters, but of no advantage for mercury interrupters.

[*Copies of some unsolicited testimonials.*]

ROYAL BUCKINGHAMSHIRE HOSPITAL,
AYLESBURY.

We are extremely satisfied with the coil. We gave it a thorough trial in all branches of X-ray work, and the results are far better than anything I have yet seen as far as current consumption, output, and absence of reverse current are concerned. We can get 5 M.A. through tube, without a trace of reverse current showing in the oscillograph.

A. C. NORMAN.

TRURO, *Dec. 23rd*, 1910.

I am delighted and astonished to find that I can get on 52 volt with 10 to 12 amps. 30 M.A. in an 8-in. air gap.

L. C. PANTING.

(This result is obtained with 52 volts; with 100 volts the coil gives 60 M.A.)

WARRINGTON, *Jan. 12th*, 1911.

I decided to have your apparatus, as everything I have had from you has been most satisfactory.

EDWARD FOX.

WEST HARTLEPOOL.

The large coil and Wehnelt break are perfection. I never have any trouble with them, and I find I can do much better and quicker work.

H. E. GAMLEN.

AUCKLAND, NEW ZEALAND,
Jan. 26th, 1911.

My new X-ray outfit has arrived, and I am very pleased with its appearance and efficiency. I find that I can get much better abdominal pictures with this new outfit than I can with the one at the Hospital (where I am Hon. Radiologist), although the Hospital coil is larger.

Yours very faithfully,
A. CLARK.

SYDNEY, *Jan. 28th*, 1911.

I am delighted with my apparatus. I must compliment you on the explicit instructions you sent out. They are perfect in detail.

A. HARRIS.

I should like to say how extremely pleased I am with your installation at the Mildmay Hospital. I have had a great number of cases lately, and in all of them the apparatus gave us complete satisfaction.

Yours sincerely,
A. L. READE.

12, Coates Crescent, Edinburgh,
Sept. 26th, 1912.

I shall be able now to work with short exposures, which is very necessary with a clumsy film in the mouth.

I must thank you for all the trouble you have taken in trying to make my difficulties easier.

You are at liberty to tell any of your customers, especially dental ones, that you have supplied me with an outfit, and that I am very much pleased with it.

I am, yours faithfully,
J. H. Gibbs.

154, Willis Street, Wellington, N.Z.
Sept. 5th, 1912.

Your letter, together with plan of apparatus, just to hand. By the aid of the plan I made a careful examination of my apparatus, and discovered as you suggested,—that I had made a faulty connection.

The apparatus is now doing all that you promised for it.

I cannot tell you how ashamed I am to have caused you so much trouble by my inexperience. Everything you supplied me with is now in good working order.

If I can ever make some return for your kindly interest in my troubles by acting as a " Reference " to possible clients, I shall always esteem it a pleasure to testify to the excellence of your workmanship, and the great interest you have displayed in assuring the satisfactory working of the apparatus supplied by you.

Yours faithfully,
Ernest Rawson.

The *British Medical Journal* of June 6th, 1908, says :—

A most successful demonstration of a method of making instantaneous X-ray exposures of the chest was lately given before a number of medical men in the electrical department of the London Hospital. Four consecutive exposures of the thorax and abdomen were made upon as many patients ; the tube was one of heavy anticathode, and although it had something like 40 or 50 milliampères driven through it several times for a fraction of a second, it appeared at the end to be indifferent to the strain. It is difficult to estimate the actual time of exposure, which was given as one-fifth of a second ; in any case it was momentary. The distance of the anticathode from the plate varied from 20 to 80 inches. With the maximum distance a slightly longer exposure, not exceeding a second, was necessary ; in this case also the shadow of the heart was reproduced on the plate in almost exactly its natural size.

The results generally were all that could be desired, and the detail of the thorax was more clearly rendered than in radiographs of the same subjects taken in the ordinary way with 45 seconds' exposure.

The *Lancet* said :—

Instantaneous Radiography.—An interesting demonstration was given on this subject at the London Hospital, when very satisfactory radiographs were made of some cases of aneurysm. While so-called instantaneous radiographs were made some years ago by several workers, it was not until quite recently that the method has been so far perfected **that it can be adopted as regular procedure, and that it has been brought within the sphere of everyday radiography.**

While **excellent results** are obtained with the tube say 24 ins. from the plate, good results are also obtained at a distance of 80 ins., and in this case **there is so little distortion that the parts are represented at almost exactly their natural size.** This, and the convenience of dealing with fretful and fidgety patients, such as children, **make this modification one of considerable value.**

Mr. C. Thurstan Holland reports about a demonstration given at the Royal Infirmary in Liverpool, in the *Lancet* of July 4th, 1908 :—

A film was exposed on a patient in the Infirmary suffering from aneurysm, and a **most beautiful result** was obtained with an exposure of a fraction of a second.

Our larger Coils (12 to 20 inch sparks) are being used, amongst others, by :—

Hospitals, etc.—Westminster Hospital, Radium Institute, National Hospital (Queen's Square), St. Mary's Hospital, St. Pancras Infirmary, Church Missionary Society, German Hospital, King Edward's Memorial Institute, Mildmay Mission Hospital, Poplar Hospital for Accidents, St. James' Infirmary.

Bedford County Hospital ; Camborne Hospital ; Cottage Hospital, Tredegar ; Croydon Union Infirmary ; Durham Co. and Sunderland Eye Infirmary ; Essex County Hospital ; General Infirmary, Burton-on-Trent ; General Hospital, Stroud ; General Hospital, Ramsgate ; Grimsby Hospital ; Kent and Canterbury Hospital ; Kingston Victoria Hospital ; Kidderminster Infirmary and Children's Hospital ; Queen's Hospital, Birmingham ; Ramsgate General Hospital ; Royal Buckinghamshire Hospital, Aylesbury ; Royal Infirmary, Derby ; Royal Infirmary, Truro ; Royal United Hospital, Bath ; Stanley Hospital, Liverpool ; South Shields Union ; Tilbury Hospital ; Infirmary, Warrington ; General Infirmary, Chichester ; Claybury Asylum ; Newbury District Hospital ; General Hospital, Tunbridge Wells.

Edinburgh Hospital for Women ; Elder Cottage Hospital, Govan, near Glasgow ; Royal Infirmary, Dumfries ; Royal Infirmary, Edinburgh ; Royal Infirmary, Glasgow ; Royal Infirmary, Berwick.

Orthopædic Hospital, Dublin ; Royal Victoria Hospital, Belfast ; South Infirmary, Cork ; Victoria Central Hospital, Liscard ; Carnarvonshire and Anglesey Infirmary, Bangor ; Tredegar Park Cottage Hospital.

War Office, Cairo ; Crown Agents for the Colonies ; India Office ; High Commissioner for New Zealand ; British Seamen's Hospital, Constantinople ; Dispensary in Jeypore ; Hospitals in Gibralter, Ceylon, Auckland, Maseru, Lahore, and Calcutta Medical Colleges ; New General Hospital, Rangoon ; General Hospital, Tongkah, Siam ; Simmer and Jack Hospital, Germiston ; Goculdas Tejpal Hospital, Bombay ; Kasur and Punjab Civil Dispensary ; Royal Prince Alfred Hospital, Sydney ; Royal Alexandra Hospital for Children, Sydney ; St. Margaret's Hospital, Launceston, Tasmania ; Wairarapa Hospital.

W. Ironside Bruce, Sir J. Mackenzie Davidson, E. S. Worrall, D. H. Freshwater, C. M. Hinds Howell, H. D. McCulloch, C. S. Morris, A. B. Roxburgh, Sir D. Salomons ; Mr. Coldwell ; V. Cotterell, Dr. Achner.

J. H. Gibbs, Edinburgh ; J. Mackintyre, Glasgow ; Prof. Ogston, Aberdeen ; W. H. Fowler, Edinburgh ; W. S. Haughton, Dublin.

F. W. Daniels, Newport ; Dr. Westmacott, Manchester.

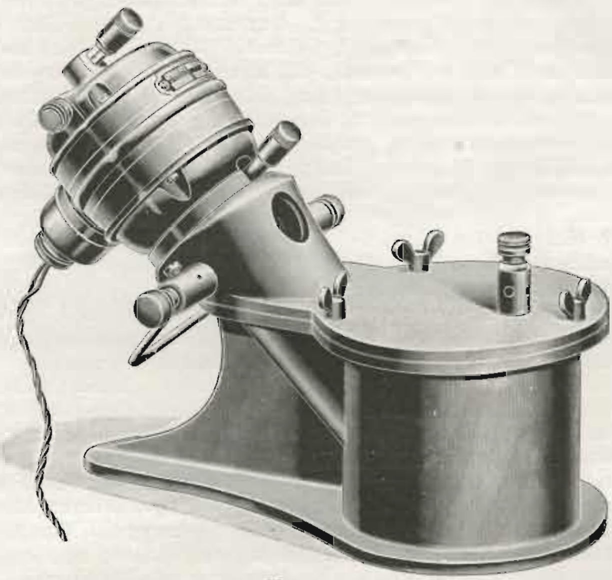
Drs. W. F. Box, Stratford-on-Avon ; R. H. Dix, Sunderland ; H. E. Gamlen, West Hartlepool ; J. Halliwell, Winchcombe ; E. H. Howlett, Hull ; F. Hernamann Johnson, Bishop Auckland ; C. E. B. Kempe, Salisbury ; J. C. Mackwood, Newick ; J. B. McKay, Newport (I. of W.) ; A. C. Norman, Sunderland ; L. C. Panting, Truro ; A. G. Paterson, Ascot ; G. Perry, Tiverton ; A. E. Rayner, Preston ; T. A. Ross, Ventnor ; G. W. Shipman, Grantham ; W. J. Weldon, Guildford ; Mr. E. A. Hoghton, Cobham ; Mr. C. J. C. Street, Lyme Regis.

A. A. Doyle, Brisbane ; Dr. Harris, Sydney ; V. H. Topalian, Diabekir ; H. E. Bamji, Bombay ; H. C. Highet, Bangkok ; A. Mackenzie, Durban ; A. M. Moll, Johannesburg ; E. Rawson, Wellington ; G. Marchesini, Auckland ; F. D. Aubin, Auckland ; J. F. Kidd, Ottawa ; R. M. Gibson, Hong-Kong ; K. H. Hekimyan, Trebizonde ; N. G. Munro, Yokohama ; Dr. Boxer, Hastings, New Zealand ; Dr. Judah, Bombay.

INTERRUPTERS.

(*See also pages* 180–181.)

SIR JAMES MACKENZIE DAVIDSON'S NEW MERCURY INTERRUPTER.



No. 2524.

At the request of Sir James Mackenzie Davidson, we have taken up the manufacture of his well-known interrupter in our workshop in London, and have, with his consent, introduced a few improvements. There can be no doubt that it is one of the best of the many types of mercury interrupters existing.

The mercury, of which 110 c.c. or 3 lbs. 4 ozs., are necessary, is placed in a circular groove and made to rotate very rapidly by the disc of insulating material which is permanently immersed in it, and which is driven by the motor. On the disc is fixed the metallic contact which makes and breaks the current.

In consequence of this disc and its permanent immersion, there is less splashing of mercury than there used to be when a blade was used which dipped in and out of the mercury at a high speed.

Coal-gas, methylated spirit, or paraffin oil can be used as a dielectric for extinguishing the sparks which are formed when the cicuit is broken. For making negatives, paraffin oil is best because more intense discharges, and in consequence shorter exposures, are obtained with it than with either alcohol or coal gas. For therapeutic purposes, however, and for all cases in which the break has to be used *several hours at a time*, coal gas is preferable, because the mercury remains quite clean. One of these new interrupters is in daily use in one of the busiest and hardest worked installations in London. After it had

been running for six months it was opened, and the mercury was found to be so clean that there was no necessity to replace it. The escape of gas is reduced to practically nil by a long cylinder enclosing the axle of the motor.

When ordering the break, please state whether it is to be used with coal-gas or methylated spirit.

There is no belt, and the motors used are of the best quality. They give a frequency of 20 to 40 interruptions per second; the latter is enough to make the light on the fluorescent screen appear perfectly steady. Sparks of great intensity are produced without causing an unnecessary amount of reverse current, a disadvantage which is bound to appertain to all interrupters with an unnecessarily high frequency.

The interrupters can easily be opened, cleaned, filled and emptied.

The motors can be arranged for any voltage on the continuous current circuit.

No. 2524. **Sir James Mackenzie Davidson's New Mercury Interrupter,** including mercury **£7 0 0**

No. 2526. **"Record" Mercury Interrupter,** 1912 type (Fig. 2526), including 10 ozs. of mercury **£10 0 0**

These breaks can be used with any voltage, from 100 up to 250, but in ordering please state the voltage of the supply with which the interrupter is to be used, so that a motor suitable for the voltage will be sent with the break.

The duration of contact can be adjusted while the interrupter is working, and the frequency of the interruptions can be varied in wide limits; the discharges can, therefore, easily be adapted to the individual tubes; intense discharges up to 30 M.A. may be reached in the tubes. The sparks obtained are uniform, the light in the tubes and on the fluorescent screens is steady. There is no flickering, no noise, and no smell.

In this break there is no jet of mercury. Instead, a small drum is put in rotation by a motor; 20 c.cm. of mercury are being centrifugated in this drum, and a copper segment makes and breaks the current once during every revolution. This allows a more perfect contact to be established than is possible with the jet; and in consequence a more intense discharge is obtained. The mercury is no longer split up in thousands of small drops, forming an emulsion, and the oxide which is unavoidably produced by the breaking sparks is separated from the mercury by the centrifugal action.

Mercury breaks give the most intense discharges which can be obtained at all from a coil, with a weak primary current, and are therefore undoubtedly the best if the supply of the primary current is limited, i.e., if accumulators, primary batteries, or small dynamos have to be used.

No. 2526.

No. 2528. **Rhythmic Mercury Interrupter,** for therapeutic purposes, Fig. 2528 (patent applied for) .. **£10 0 0**

This interrupter has been constructed to switch the current on and off for a short time, at frequent intervals, to give the tubes time to disperse the heat by radiation. The tubes can then be used for long exposures without becoming unduly hot and soft.

In using X rays for therapeutic purposes, for instance for treating myomatas, it is necessary to apply doses of 2 to 5 M.A. for four to six minutes, i.e., about 20 milliampère minutes, and many tubes will not stand such a current at a stretch without becoming soft, whereas most tubes can stand even much stronger currents for *short* periods, say a quarter of a second at a time, quite well if a pause of half a second or a second is given between two impulses.

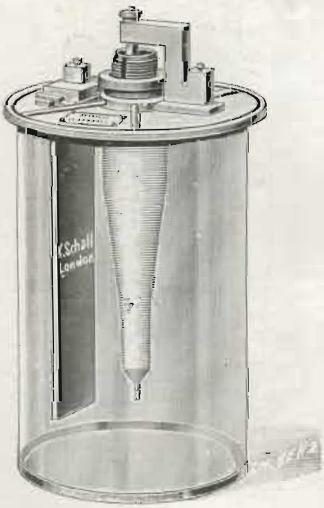
The interrupter does not replace the ordinary mercury or electrolytic interrupters, but has to be used in addition to them. The duration of the time during which the current is on and off can be varied in wide limits. The green light in the tube appears and disappears just as the light of a lighthouse. Four interrupters of this kind are in daily use at a Gynæcological Clinic since about a year, with most satisfactory results.

As supplied to the Westminster Hospital, Cancer Hospital, Dr. Worrall, etc., etc.

No. 2528.

Dr. Wehnelt's Electrolytical Interrupters.

(*See also pages* 180–181.)



No. 2530.

No. 2531.

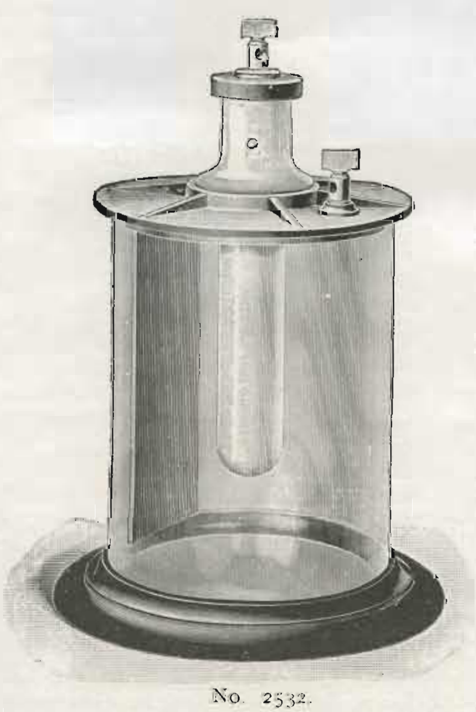
No. 2530.	**Platinum,** 1 mm. thick, 40 mm. long	£3 4 0
No. 2530*a*.	**Platinum,** 2·5 mm. thick, 40 mm. long, Fig. 2530 ..	5 0 0

Diameter of the glass jar 8 ins., height 10½ ins. The screw for varying the length of the exposed part of the platinum is of stout ebonite, and cannot stick or corrode. If some oil is poured over the acid, no vapour can escape.

No. 2531.	**Similar Interrupter** with 3 anodes, one with 1 mm. and two with 2·5 mm. platinum wire, Fig. 2531 ..	10 0 0
No. 2531*g*.	**Similar Interrupter,** with 3 thick anodes, for instantaneous exposures	12 0 0
No. 2531*r*.	**Similar Interrupter,** with 4 anodes; 3 with thick wire for instantaneous exposures, and one with thin wire for examination on the screen.. ..	14 0 0

No. 2531*z*. Our **Wehnelt Interrupters** can be made *perfectly silent* by adding our rubber air cushion over the porcelain tube, near the anode (see Fig. 2531*z*)
Price **£1 2 0** each

No. 2531*z*.



No. 2532.

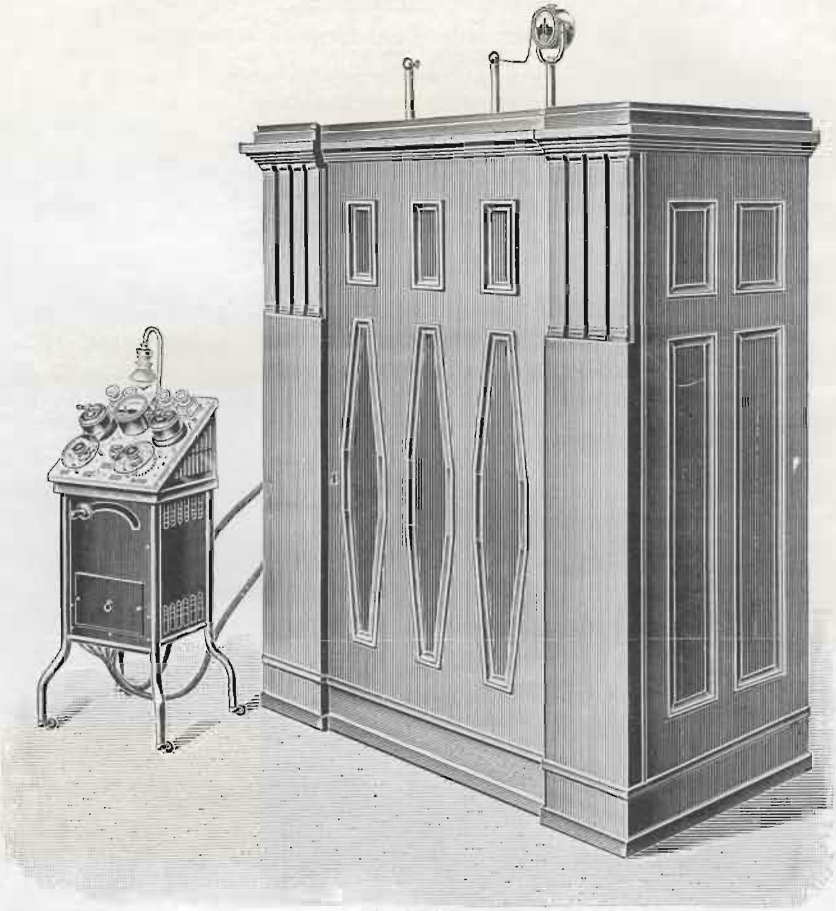
No. 2532.	**Simon or Caldwell Interrupter,** *Fig.* 2532	£2 5 0
No. 2533.	**Similar Interrupter,** with 3 tubes for instantaneous exposures	3 14 0
No. 2533*c*.	**Similar Interrupter,** with 3 tubes for instantaneous exposures, and a fourth tube for time exposures, or examination on the screen ..	4 0 0

Motor Transformers, *to convert the Alternating into a Continuous Current,* will be found under Nos. 2680–2684.

TRANSFORMER,

For producing X Rays without Interrupter.

(*See also pages* 182–183.)



No. 2536.

In this apparatus an alternating current is transformed to a voltage sufficiently high for X-ray purposes, and the waves are made unidirectional by means of a current reverser driven by a synchronous motor.*

Our apparatus is enclosed in a cabinet, which effectually deadens the unpleasant noise caused by the motor and rectifier. Moreover, it is so arranged that for examination on the screen, for time exposures, or for therapeutic purposes, one phase only may be used; both phases are employed only when very short exposures are desired.

* The apparatus was invented by Mr. Koch, and described in 1904 in *Annalen der Physik*, *Engineering*, *English Mechanic*, and *Fortschritte auf dem Gebiet der Röntgenstrahlen*. Five years later Mr. Snook, of Philadelphia, constructed a similar apparatus, and its present size and appearance are due to him.

The price of a complete apparatus, including switchboard with ampèremeter to control the output, and a milliampèremeter to measure the current through the tube, is :—

No. 2535.	For an **alternating** current supply, with synchronous motor to work the rectifier	**£160 0 0**
No. 2536.	For a **continuous** current supply, with a motor transformer of 4 kilo Watt, Fig. 2536	**170 0 0**
No. 2537.	Similar Apparatus, but smaller size, for an **alternating** current	**110 0 0**
No. 2538.	For a **continuous** current	**128 0 0**

With the Apparatus Nos. 2535 and 2536, currents of 35 milliampères can be obtained through X-ray tubes of medium penetration No. 8·0 Wehnelt scale, or up to 60 M.A. through soft tubes.

With Apparatus Nos. 2537 and 2538, currents of 15 milliampères can be obtained through No. 9 Wehnelt tubes.

This kind of apparatus is being recommended by one firm as being superior in efficiency to spark coils. We do not agree with this view, and will state our experience, which is based on many experiments and careful comparison, and on the experience of several owners of these apparatus.

Excellent negatives with short exposures can undoubtedly be obtained with high tension transformers of this kind, especially of those parts of the body which require soft rays. The apparatus are simple to manage, the discharge is well under control, no interrupter and no valve tube are required, as there is no reverse current.

On the other hand, they are not as suitable for therapeutic purposes as spark coils are, partly because they heat the tubes to a greater extent, but chiefly because it is more difficult to obtain the *hard* rays which are indispensable for most therapeutic purposes, because all tubes are softer when connected with such a transformer than when connected with a spark coil ; the explanation of this fact will be found on page 183.

Moreover, a 4 kilowatt transformer, costing £170, does *not* give better quality negatives or shorter exposures than a modern first-class 16-inch coil, which costs, including switchboard, interrupter, M.A. meter, etc., etc., about £90, i.e., half the price, for a *continuous* current installation. On an *alternating* current circuit the difference in price is not nearly as great, because a motor transformer is required to make a spark coil really efficient, and this will increase the above-mentioned price by about £45, so that for alternating currents the difference between coil and transformer is only a slight one.

Our opinion is corroborated by the experience of several prominent specialists in the X-ray world ; some of them use interrupterless transformers since several years, another tried one for over three months, before deciding, and after having made over a hundred exposures with it, he admitted fully the high quality of the negatives and the short exposures, but as the results were not *better* than those obtained with a first-class coil, he considered the extra cost of the transformer unnecessary, and decided for the coil.

We know that another authority considers the interrupterless transformer as more efficient than a coil, but it depends of course with what quality of coil and interrupter the comparison is made. There is no doubt that the transformers give much better results than could ever be obtained with older coils ; our contention is only that they are in no way *better* than those which can be reached with the best modern coils and interrupters.

This is more fully explained on pages 182–183.

The fact that 50 to 60 M.A. can be reached through a soft X-ray tube with a high tension transformer, whereas with a good 12 to 16 inch spark coil and a mercury interrupter only 20 to 25 M.A. may be reached through the same tube, has led

many people to the belief that the interrupterless transformer is bound to give shorter exposures than a coil, but this is not the case, because with a spark coil the *quantity of X-rays obtained per M.A. of current is greater than that obtained with high tension transformers* on account of the different character of the discharges.

It has to be remembered, too, that if shortness of exposure is of prime importance, the interrupterless transformers have undoubtedly been beaten by the large spark coils and mercury interrupters which give good negatives of the heart, stomach, etc., of adults with *one single spark* only, i.e., in about the $\frac{1}{200}$th part of a second, and these apparatus are about the same price as the high tension transformers.

FOCUS TUBES.

(*See also pages* 186–199.)

Good quality and suitable penetrating power of the focus tubes are *all important* for obtaining good negatives. The rays should be of such a quality that they can be stopped by the object of which we wish to see the shadow on the negative, but that they can penetrate yet through the surrounding tissue of smaller atomic weight. If the penetrating power is too small, the X rays are absorbed and stopped before they reach the plate, and the negative will show clear glass patches. If it is too great, the X rays will penetrate not only the soft parts, but bones, etc., as well, and the result will be a foggy negative, without contrasts and fine details.

The penetrating power can be measured by means of radiometers Nos. 2735–40. On page 191 it is explained how tubes can be made harder or softer.

It is *economical* to have several tubes in use to suit the various parts of the body: one soft one for hands, arms, etc., two medium for chest, kidneys, knee, etc., and one hard one for pelvis and for examination on the screen. If all exposures are attempted with *one* tube only, either the quality of many negatives will be poor, or else the vacuum has to be altered pretty frequently to adapt the tube to thin or thick parts, and this means waste of the lifetime of the tubes and loss of the time of the operator.

Focus tubes can be supplied either with a very fine sharp focus, or with the normal moderately sharp one, or with a blunt focus. In the latter case the tubes are for therapeutic purposes only, and are useless for making negatives. Owing to the fact that the cathode rays do not converge on a point, but are distributed over a circle nearly a centimeter in diameter, the heat is distributed more evenly and does not reach such a high degree, and these tubes have a considerably longer life. They are marked with a T.

The tubes with a moderately sharp focus are most frequently used, and are the normal type of tubes to which we have hitherto been accustomed. The focus has a diameter of 1 to 1½ m.m., and gives sufficiently sharp definition for the great majority of cases. These tubes can stand yet strong currents without melting of the anticathode.

Recently, tubes with a focus as small as a needle's point have been introduced. They give the sharpest definition obtainable, and in some cases

—for instance for finding diseases of bones, making negatives of the head—they are better than the normal tubes. These sharp focus tubes are marked with a point in the centre of a ring. The heat and strain are greater in these tubes than in the others; currents of 10 to 15 milliampères will melt the platinum of the anticathode in a short time, and they do not therefore last quite as long; this is the reason why it is not advisable to use them for all cases. The prices of the tubes remain the same, whether they are made with a blunt, a normal, or a sharp focus, and we keep all three kinds in stock. If not otherwise ordered, we supply the tubes with a normal focus.

For every tube there is a "normal" current, with which it will keep constant. In new tubes this is comparatively small, but if the tubes are properly treated it increases steadily, and tubes which have become seasoned by a number of exposures will stand a much stronger current than new tubes. This is more fully explained on page 190. If *less* than the "normal" current is given, the tubes become *harder*. If *more* than the normal current is given, the tubes become *softer*. For a very short time, fractions of a second, the normal current can, however, be exceeded even fifty times without fear of damage, provided tubes with heavy anticathodes are being used.

Milliampèremeters No. 2721, are the most convenient and reliable help to find out whether a tube has its normal current, or too much or too little.

Reverse current shortens the lifetime of the tubes, deteriorates the quality of the negatives, and should be carefully excluded; see pages 193–195.

Tubes should be placed fully 5 feet away from either pole of the spark coil. The glass should be dry and free from dust.

Tubes which have been used already for many exposures are not worth repairing, because after re-exhaustion they become hard too rapidly. The metal parts of some of the tubes are of some value, and will be credited when a new tube is taken instead.

For the length of exposure required for making negatives, or for the dosage for therapeutic purposes, see pages 199 and 228–229.

If not otherwise ordered, tubes will be delivered which have an equivalent spark gap of $3\frac{1}{2}$ to 4 in. *All tubes are tested carefully* by us before they are delivered, and the equivalent spark gap and the penetration in Wehnelt units are written on a label attached to the neck of the tube.

Focus tubes are gradually worn out by use, but those which are properly treated will last for hundreds of exposures, whereas with carelessness or through want of skill and knowledge, even the best tube may be damaged or destroyed during the first exposure.

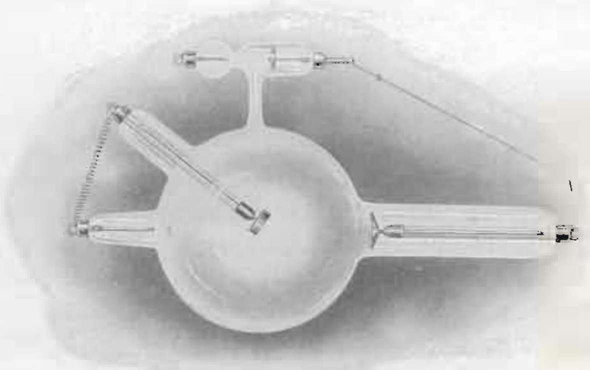
This is the reason why X-ray tubes have to be excluded from the one year's guarantee given with our apparatus. We select tubes with the penetrating power desired by our customers, we test and pack the apparatus most carefully, and insure them against breakage,—but after this our responsibility is at an end.

The tubes Nos. 2530 to 2580 are provided either with the automatic regulation to lower the penetrating power, or, if desired, with the osmo regulation, or they can be fitted to order with the Bauer valve.

More particulars about the regulation or regeneration of the vacuum will be found on pages 191–192.

The tubes Nos. 2530 to 2532 are suitable only for weak currents not exceeding about 1·5 milliampères. Tubes Nos. 2540 to 2561, etc., are suitable for the currents most frequently used, i.e., from 2 to 5 milliampères, but for exposures of short duration much stronger currents may be used. Nos. 2543, 2555, and Nos. 2570 to 2582 are suitable for stronger currents; and Nos. 2544, 2545, 2555, and 2582 are made specially for the heavy currents used for instantaneous and tele-exposures.

X-RAY TUBES.



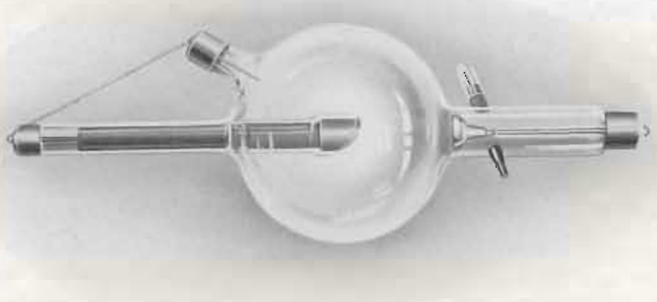
No. 2539*b*.

No. 2539*a*. Diam. 4½ in. **£1 8 0**

No. 2539*b*. Diam. 5½ in. **£1 12 6**

No. 2539*c*. Diam. 6½ in. **£2 2 0**

The anticathodes of these tubes consist of a thick disc of copper covered with a sheet of platinum.

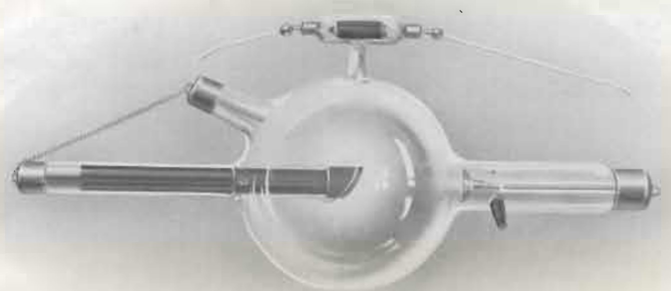


No. 2542, with Osmo Regeneration.

Tubes with heavy anticathodes, covered with a platinum foil, and mounted on a metal cylinder which is enclosed in a glass tube to reduce the secondary rays.

The prices quoted *include* the advance in cost of platinum.

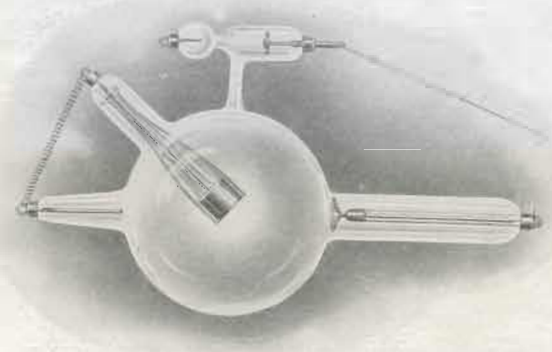
If desired, the anticathode of the tubes Nos. 2543 to 2545 and No. 2570 can be fitted with a solid platinum disc **half a millimeter thick.** The advantage of this is that even strong currents cannot perforate the platinum. The additional cost is 20/–, but when the tubes have been used up, these solid platinum targets can be used again for new tubes, or else an allowance can be made for the old platinum



No. 2542, with Automatic Regeneration.

No. 2540.	Diam. $4\frac{3}{4}$ in. ..	..	£2	4	0
,, 2541.	,, $5\frac{1}{2}$ in. ..	..	2	6	0
,, 2542.	,, $6\frac{1}{2}$ in. ..	..	3	0	0
,, 2543.	,, 8 in. ..	..	3	10	0
,, 2544.	,, 8 in. Moment .	..	4	4	0
,, 2545.	,, 10 in. ,,	..	4	12	0

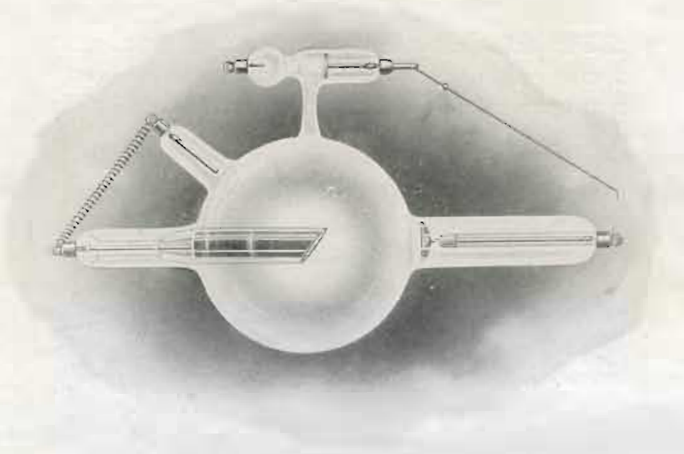
The tubes No. 2544 and 2545 are specially exhausted to stand the strong currents used for instantaneous and tele-exposures. This applies also to the Mammoth tube No. 2555, mentioned below.



No. 2551.

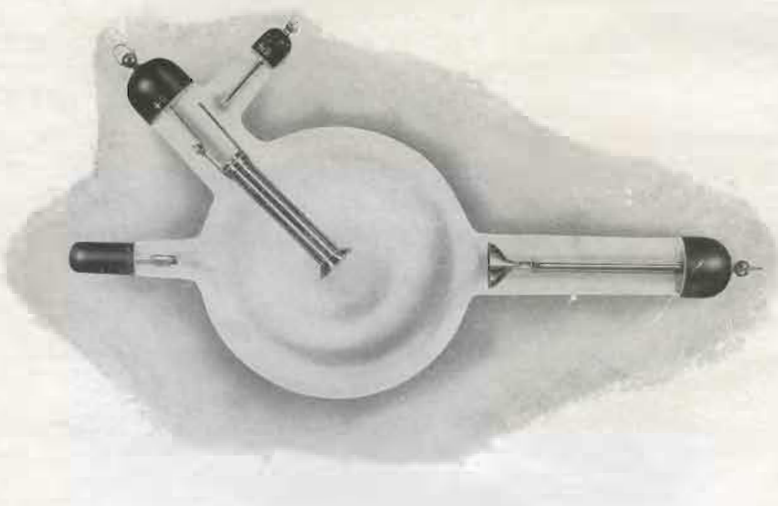
Similar tubes, of another make, shown in Fig. 2551 :—

No. 2551.	Diam. $5\frac{7}{8}$ in. ..	..	£2	12	6
,, 2552.	,, $6\frac{11}{16}$ in.	..	2	17	6



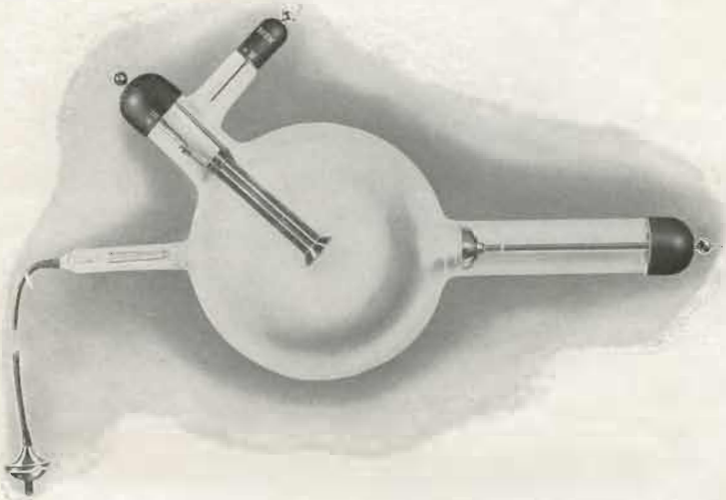
No 2553.

No. 2553.	Diam. 8 in., Fig. 2553	£3	7	6
,, 2555.	,, 8 in., "Mammoth"	4	5	0
,, 2557.	**Bauer Tube**, with air-cooled anticathode, and with choking coil to reduce reverse current, diam. 8 in.	4	5	0



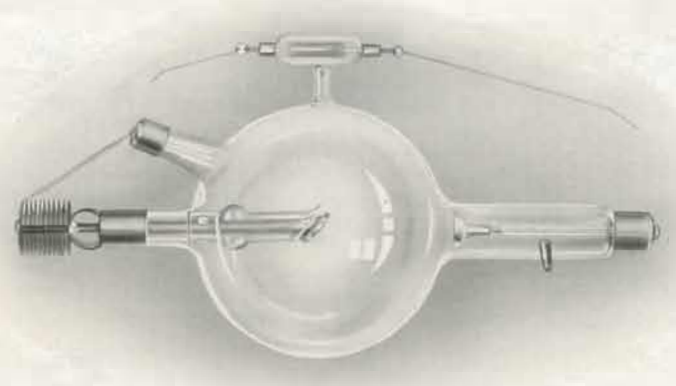
No 2559.

No. 2559.	Bauer "Delta" Tube, Fig. 2559, diam. 8 in. ..	4	5	0
,, 2561.	Similar tube, with Bauer air regulation, Fig. 2561	5	5	0
,, 2563.	Air pump, to work the air regulator at a short distance	0	2	6
,, 2564.	Air pump, to work the air regulator at a long distance, while the tube is working	0	12	6



No. 2561.

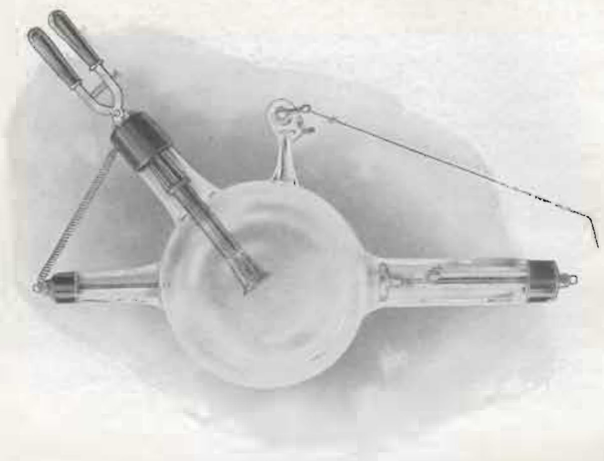
Tubes with rib cooling, made specially for exposures or examinations of long duration (for therapeutic purposes, or for examination on the fluorescent



No. 2570.

screen). Even with prolonged use of strong currents the ultimate temperature cannot exceed 200 degrees Centigrade. The tubes offer the same advantages as water-cooled tubes, but can be used in any position.

No. 2570. Diam. 8 in., Fig. 2570 .. .. .. **£6 2 0**



No. 2571.

No. 2571s.

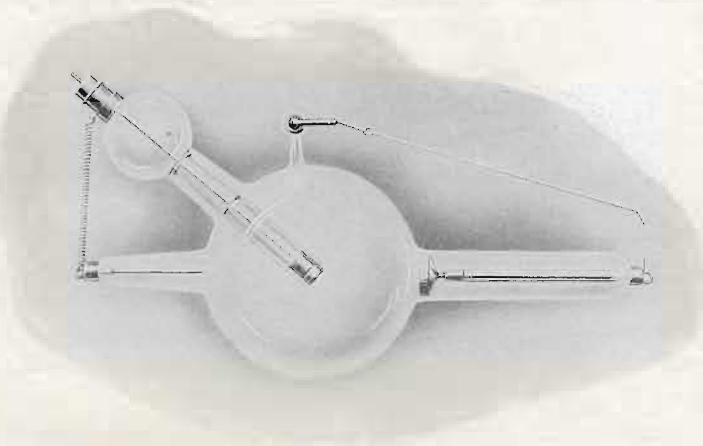
No. 2571*w*

No. 2571*r*

No. 2571.	Diam. 8 in., Fig. 2571 (without tongs) ..	..	£5 17 6
,, 2571s	Simple tongs	..	0 17 6
,, 2571w	Water-cooled tongs for No. 2571, Fig. 2571*w*	..	0 17 6
,, 2571r	Radiator tongs for No. 2571, Fig. 2571*r*	..	1 2 6

WATER-COOLED TUBES.

In these tubes, water comes in direct contact with the platinum of the anticathode, to keep it cool. They can stand, therefore, comparatively heavy currents for long exposures without becoming overheated. They are provided with automatic regulation, or can be fitted with the new Bauer air regulation. These tubes should never be used without water being in; there is risk of instant breakdown if this is overlooked.



No. 2577.

No. 2575.	Diam. $6\frac{3}{4}$ in.	£5 5 0
,, 2577.	,, $7\frac{7}{8}$ in.	6 0 0
,, 2578.	,, $9\frac{7}{8}$ in.	8 0 6

Similar tubes, but so arranged that they may be also used below the couch :—

No. 2579.	Diam. $6\frac{3}{4}$ in.	£6 5 0
,, 2580.	,, $7\frac{7}{8}$ in.	7 2 6
,, 2582.	The "Rapid" water-cooled tube (similar to Fig. 2577), diam. 8 in., suitable for heavy current ..	6 5 0

TUBES with Anticathodes of TUNGSTEN, Chabaud, Burger, etc., etc., tubes not yet described in this List, can be supplied at the manufacturers' prices.

No. 2599.

No. 2599.	Spirit Lamp, on long insulating ebonite handle, to warm the tubes, or the palladium tube while the tubes are working, Fig. 2599	£0 9 6
No. 2596.	Arrangement to control the automatic regulation of X-ray tubes from a distance, while the tubes are working	0 16 6

VALVE TUBES, SPARK GAPS, ETC., TO SUPPRESS THE REVERSE CURRENT.

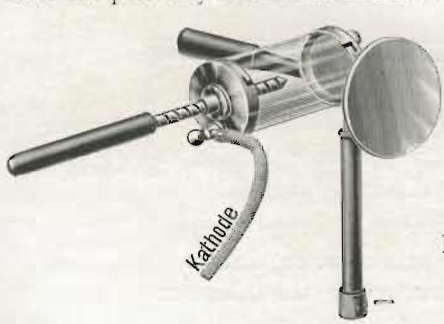
With currents of weak or moderate strength, up to about 6 milliampères there is no reverse current with our new coils and mercury interrupters. If this strength is not to be exceeded for the *short* exposures required to make negatives, special arrangements to suppress the reverse currents are not necessary.

When the tubes are to be used for exposures of *long* duration (for therapeutic purposes), which is a great strain on them, or with strong currents, exceeding 10 milliampères, or if electrolytic interrupters are to be used, it is necessary to use spark gaps or valve tubes to suppress the reverse current, for reasons which have been explained on pages 193–195. With many old coils valves have to be used with weak currents already.

A moderate amount of reverse current can be suppressed efficiently by spark gaps like No. 2600. They are convenient and economical, because they do not become used up like the X-ray or valve tubes. They are to be attached to the *negative* terminal of the coil, so that the plate of the spark gap is near the – pole (plate terminal) of the coil, and the point side of the spark-gap is to be connected with the cathode of the tube. When not wanted it can be switched off by screwing the point home so that it touches the plate. For good modern coils with mercury interrupters these spark gaps are quite sufficient.

With the strong currents obtained with multiple electrolytic interrupters for instantaneous exposures, an arc tends to form in the spark gap, and the *arc* does *not* rectify. In these cases the valve tubes are better. The outer cylinder of the valve tube has to be connected with the – pole (the plate terminal) of the spark coil, the inner one with the cathode of the X-ray tube. The valve tube may be suspended near the coil, and the distance between it and the X-ray tube should not be less than about six feet. The equivalent spark gap of the valve tubes should be about ¾ inch. They are provided with regeneration arrangement to lower the vacuum.

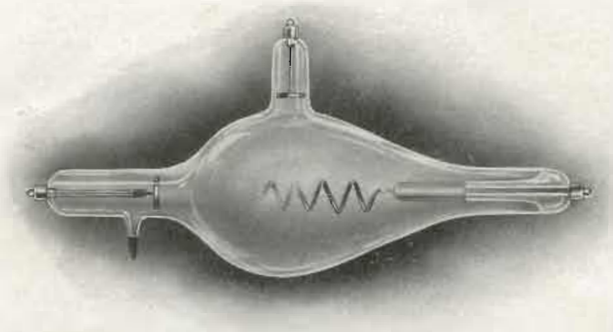
It is inconvenient to have to connect and disconnect the valve tubes each time, and on the other hand it is a waste of the lifetime of the valve tubes to leave them in the circuit all the time, even while currents free from reverse current are being used. The green light of the valve tubes is inconvenient too when examinations on the fluorescent screen are being made. We have, therefore, constructed a special valve tube holder with a *bipolar* high tension change over switch (Fig. 2608). By pulling a silk cord the tubes can be switched on; by pulling a second cord, both poles are disconnected, and the tube is switched off. The holder can thus be fixed high up, so that the tube and connections are out of the way. A single pole switch will not do for this purpose, as fluorescent light appears even while one pole only remains connected with the coil.



No. 2600.

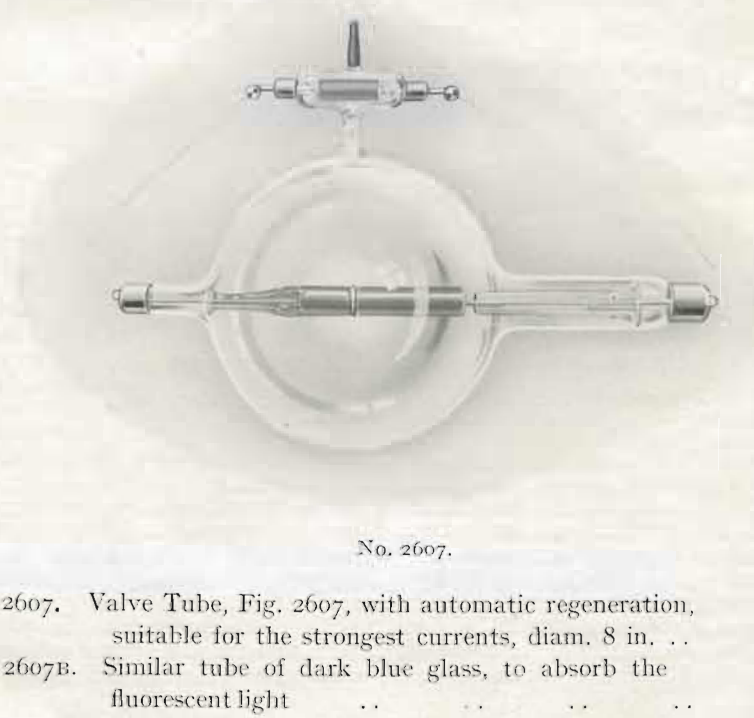
No. 2600. **Adjustable Spark Gap,** *Fig.* 2600, to suppress the closing current **£0 17 0**

No. 2601.	Valve Tubes, for currents of medium strength, with osmo regeneration, diam. 6 in.	£1 5 0



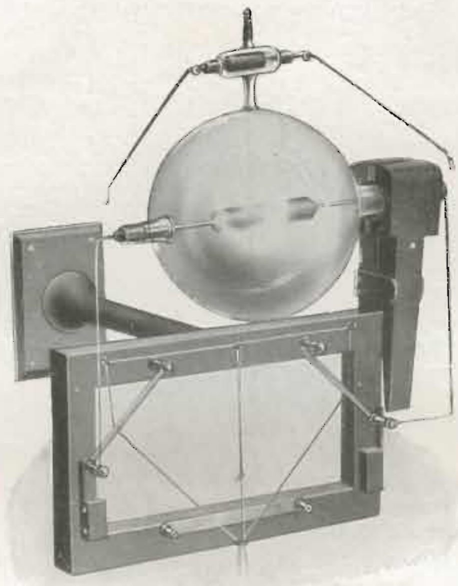
No. 2603.

No. 2601.	A Similar Tube, diameter $7\frac{1}{2}$ in...	1 9 0
No. 2603.	Villard Valve Tube, Fig. 2603	1 7 6
No. 2605.	Sir Oliver Lodge Valve Tube	2 0 0



No. 2607.

No. 2607.	Valve Tube, Fig. 2607, with automatic regeneration, suitable for the strongest currents, diam. 8 in. ..	1 14 0
No. 2607B.	Similar tube of dark blue glass, to absorb the fluorescent light	2 6 0



No. 2608.

No. 2608.	Valve Tube Holder, Fig. 2608, with **double pole** high tension change over switch, to suspend the valve and tube on cabinet or wall, and switch it on or off from a distance	£1 15 0

No. 2609.

No. 2609.	Oscilloscope Tube, 6 in. long, Fig. 2609, to indicate the presence and amount of reverse current ..	0 16 0
No. 2610.	A similar tube, but 9 in. long, better quality, and filled with helium	1 12 0

It is a great convenience to have an oscilloscope tube in the circuit, as it reveals the presence and intensity of any reverse current. As long as there is a current in one direction only, one only of the two aluminium bands in the tube is surrounded by a purple fluorescence. The length of the band is an indication of the intensity of the discharges. If there is a current in the wrong direction the second aluminium band shows fluorescence too. If both aluminium bands show fluorescence of the same length, the strength of the closing current is as great as the strength or intensity of the breaking current, and the M.A. meter will remain at zero. The illustration 2612*m* shows an oscilloscope tube suspended on a tube stand.

STANDS TO HOLD X-RAY TUBES, DIAPHRAGMS AND COMPRESSORS.

No. 2611. Large Stand, *Fig.* 2611, 5 feet high from floor .. **£2 10 0**

The heavy iron base is provided with castors, as well as with screws to fix it in a certain position, if desired.

(As supplied to St. Bartholomew's Hospital, Royal Infirmaries in Edinburgh, Glasgow, Belfast, etc., Dr. Lewis Jones, etc., etc.)

The Stand No. 2611 can be used for the suspension of X-ray tubes, and in addition a valve tube and a galvanometer for measuring the currents can easily be fixed on it, as shown in Fig. 2611 (this convenient arrangement was first suggested by Dr. Lewis Jones). The connections are also shown; the wires marked + and - lead to the corresponding terminals of the spark coil.

No. 2611.

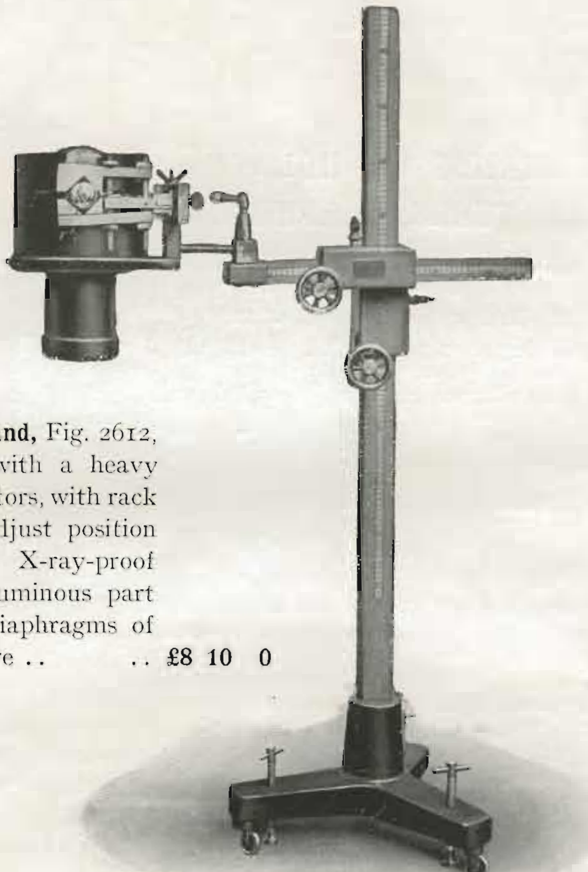
Our Tube Stands No. 2612 have been supplied, amongst others, to :—

Charing Cross Hospital, Mildmay Mission Hospital, National Hospital for Diseases of the Heart, Poplar Hospital for Accidents, Royal Waterloo Hospital for Children and Women, St. Bartholomew's Hospital, St. James' Infirmary, St. John's Infirmary, St. Pancras Infirmary, University College Hospital, Westminster Hospital.

Bedford County Hospital; Croydon Union Infirmary; Cumberland Infirmary; Essex County Hospital; General Hospital, Bristol; General Hospital, Ramsgate; General Hospital, Stroud; General Hospital, Tunbridge Wells; General Hospital, Wolverhampton; General Infirmary, Stafford; The Hospital, Diss; The Infirmary, Kidderminster; Kingston Victoria Hospital; Kingston Union Infirmary; North Staffordshire Infirmary; Radcliffe Infirmary, Oxford; Royal Infirmary, Liverpool; Royal Buckinghamshire Hospital, Aylesbury; Royal Sea Bathing Hospital, Margate; Royal United Infirmary, Bath; Victoria Central Hospital, Liscard.

County Hospital, Ayr; Edinburgh Hospital for Women; Royal Infirmary, Aberdeen; Royal Infirmary, Dumfries; Royal Infirmary, Glasgow; Royal Alexandra Hospital, Paisley; Royal Infirmary, Berwick; City Infirmary, Waterford.

Tredegar Park Cottage Hospital; Victoria Central Hospital, Liscard.



No. 2612. **Tube Stand,** Fig. 2612, made of oak, with a heavy iron foot, on castors, with rack and pinion to adjust position of tube, with X-ray-proof box to cover luminous part of tube, and 3 diaphragms of different aperture **£8 10 0**

No. 2612.

Goculdas Tejpal Hospital, Bombay; The Hospital, Dunedin; Kasur Punjab Civil Dispensary; Medical College, Lahore; Crown Agents, Uganda.

Sir J. Mackenzie Davidson, C. M. Hinde Howell, H. Lewis Jones, C. S. Morris, R. Morton, H. Walsham, E. S. Worrall, Sir D. Salomons.

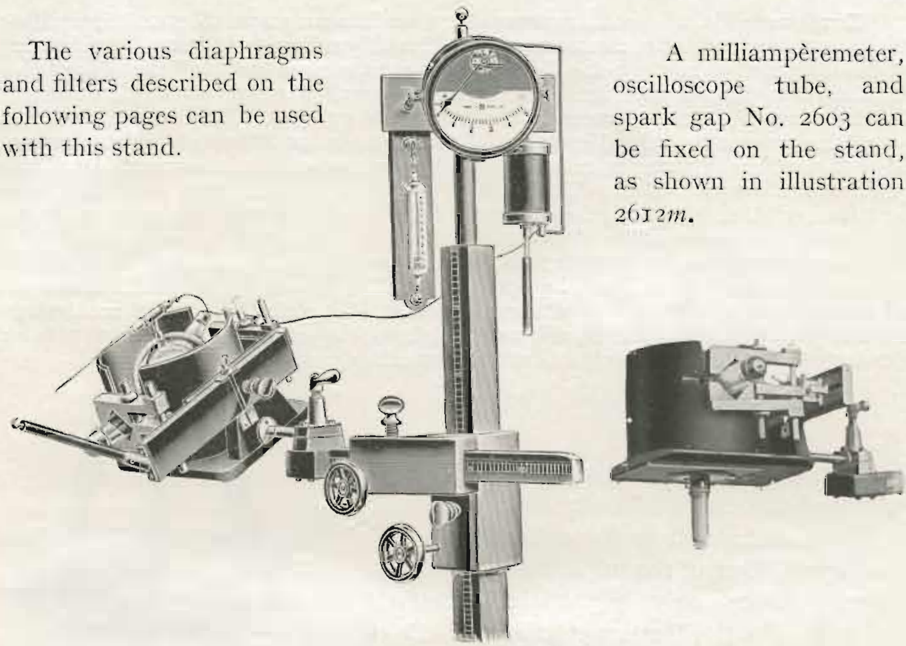
N. E. Aldridge, Southampton; J. A. Codd, Wolverhampton; W. Coleman, Reading; A. E. Cox, Watford; E. Fox, Warrington; V. J. Greenyer, Hove; A. R. Hallam, Sheffield; C. J. Heaton, Margate; J. Hussey, Farnham; F. Hernaman Johnson, Bishop Auckland; A. H. John, Stoke-on-Trent; J. C. Mackwood, Newick; A. G. Paterson, Ascot; G. Perry, Tiverton; T. A. Ross, Ventnor; R. C. S. Slater, Godalming; W. K. Wills, Clifton.

J. H. Gibbs, Edinburgh; J. G. Grahame, Glasgow; R. Morton, Glasgow; S. Sloan, Glasgow; J. B. Simpson, Golspie; J. W. White, Glasgow; E. F. Price, Edinburgh; Dr. W. Furlong, Dublin; W. F. Brook, Swansea; F. W. Daniels, Newport.

R. St. M. Dawes, S. Australia; J. F. Kidd, Ottawa; R. M. Gibson, Hong-Kong; V. H. Topalian, Diarbekir; E. Yeates, Johannesburg; E. D. Aubon, Auckland, New Zealand.

The various diaphragms and filters described on the following pages can be used with this stand.

A milliampèremeter, oscilloscope tube, and spark gap No. 2603 can be fixed on the stand, as shown in illustration 2612*m*.



No. 2612*m*.

No. 2613. **Cylinder Diaphragm** for 2612 .. .. .. £0 10 6

An **Iris Diaphragm,** No. 2627, can be used with this stand, price .. .. .. extra 1 18 0

No. 2614*a*.

Nos. 2614–2614*c* have been specially made for the convenient treatment of *ringworm*, and fit into the Stands Nos. 2612, 2615, and 2620.

No. 2614. **Diaphragm** with a pastille holder, to expose Sabouraud's pastilles at distances varying from 6 to 12 cm. from the anticathode £1 2 6

No. 2614*a*. Four lead glass **Funnels,** with apertures of 1, 2 ,3, and 4½ ins., for treating ringworm (Fig. 2614*a*) .. 1 5 0

Diaphragm No. 2614 enables us to adjust the Sabouraud pastilles at *half* the distance used between anticathode and skin. It is only necessary to know the diameter of the tube, and to measure the distance between the glass bulb and the edge of the diaphragm resting on the skin. The former is usually known, or can be obtained by measuring the circumference of the bulb with a thread. The circumference is 3·14 times greater than the diameter. If the tube has, for instance, a circumference of 37·6 ctm., its diameter is 12 ctm., and the distance of the anticathode from the glass wall is 6 ctm. If the distance between glass wall and skin is 15 ctm., the pastille should be exposed at a distance of 10·5 ctm. from the anticathode, or 4·5 ctm. from the glass wall.

The ebonite rod, carrying at its end the pastille, is first pushed home till it touches the glass bulb of the tube; at this point it is, with a tube of the diameter mentioned above, 6 ctm. from the anticathode. We look then at the centimeter scale engraved on the ebonite rod, and withdraw it 4½ ctm. to have the pastille at the desired distance of 10½ ctm. from the anticathode.

No. 2614*c*. **Dr. Adamson's Tripod,** with wooden rods, to keep the head at a fixed distance from the anticathode, for epilation of the *whole* head, with 5 exposures only, Fig. 2614*c*. The tripod fits the Diaphragm 2614 **£0 6 0**

No. 2614*c*.

No. 2614*f*. **Aluminium Filters,** 1, 2, 3 or 5 mm thick, fitting into the Stand No 2612 .. .. .. **£0 3 0**

No. 2614*r*. **Diaphragm** for dental purposes, with a cylinder to centre the tubes, so that the central ray strikes the part to be exposed perpendicularly **3 10 0**

A description of the technique of treating Ringworm with X rays will be found on pages 222–226.

X-RAY TUBE STAND,

With Flat Diaphragm, Cylinder Diaphragm, and Compressor.

The **Stand** shown in illustration (Fig. 2616, p. 258) is 6 feet high, and is mounted on castors. The tube is suspended in *our New Self-centering Tube Holder*, which enables the operator to fix a tube in correct position above the cylinder diaphragm without losing any time in centering it, without having to keep the tube alight for this purpose, and without having to expose his hands. Tubes of different penetrating power can thus be exchanged easily.

Below the tube is a flat diaphragm, the aperture of which can be adjusted with rack and pinion. The stand can either be used for photographic exposures with or without a compressor, or for examination on the fluorescent screen, or

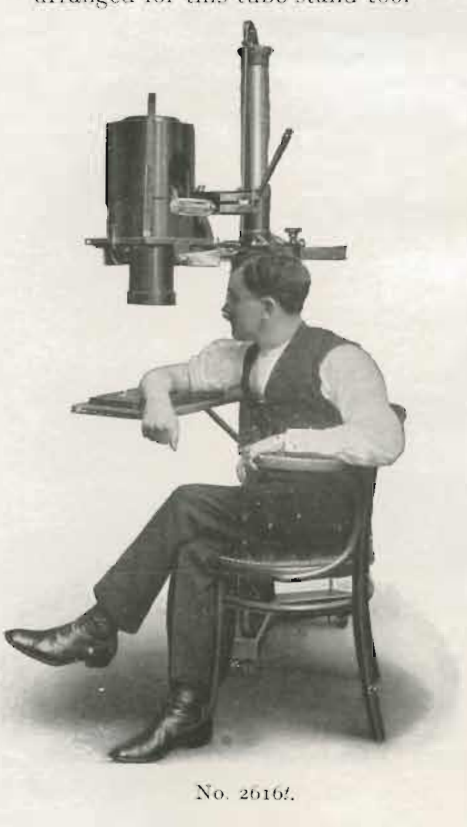
for therapeutic purposes. Tube and diaphragm can easily be raised or lowered, and can be used in vertical, horizontal, or any other position. The tubes can be used equally well above or below the couch (see illustration on page 259).

A cylinder diaphragm can be slipped in below, to make exposures with compression. The cylinder diaphragm can be provided with a pneumatic ring as cushion; it can be inflated by means of a rubber bellows, and grasps the skin of the patient firmly, without giving pain.

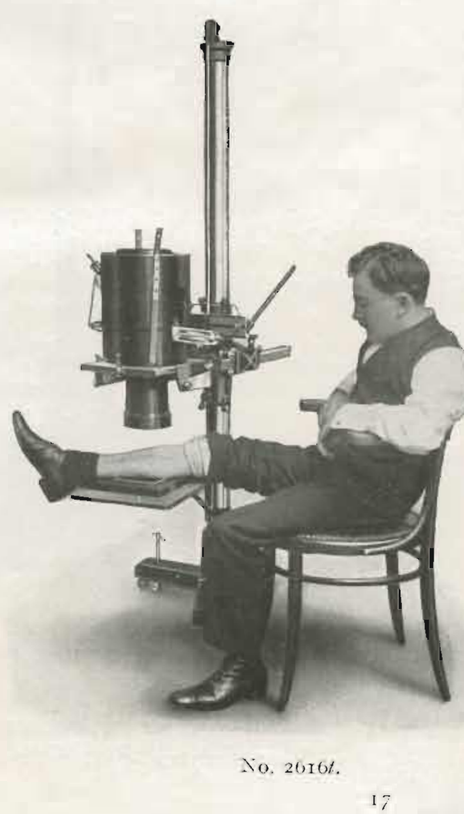
No. 2616.	Price of **Stand,** including box lined with X-ray-proof rubber, to prevent any X rays or green light reaching the room (the box encloses the tube entirely, and gives *perfect protection to operator and assistants*), self-centering tube holder, flat diaphragm, No. 2628, and cylinder diaphragm Fig. 2616 ..	**£25**	**0**	**0**
	Price of **Pneumatic Cushion**	**1**	**9**	**0**

The box can be so arranged that it can be moved up to 7 ctm. each way from the centre, *without disturbing the position of the patient, or interfering with the cylinder compressor.* It is then suitable for exposing plates to be examined with a stereoscope. The extra cost of this arrangement, including scale, is **£3 3**s.

The Diaphragm No. 2614, for exposing Sabouraud's pastilles can be arranged for this tube stand too.



No. 2616*l*.

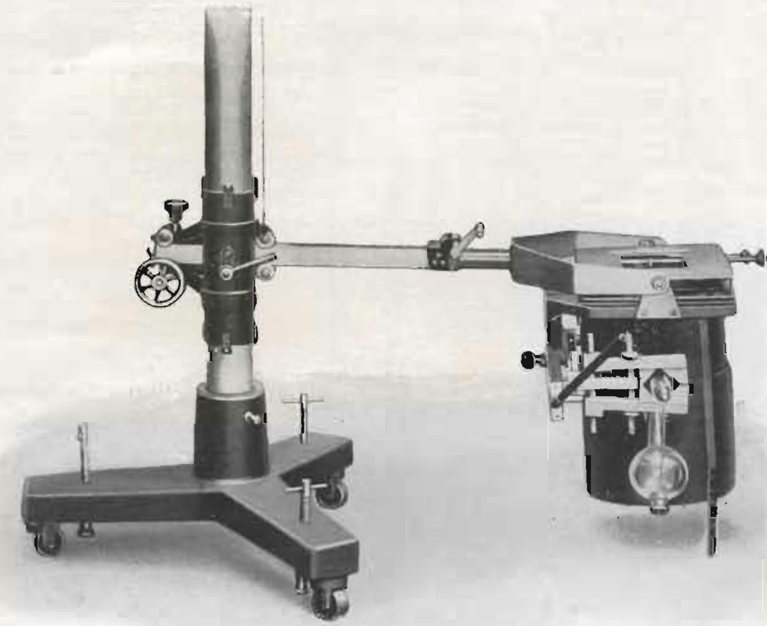


No. 2616*t*.

No. 2616.

No. 2616*t*. A Table can be attached to the Stand, as a firm support, for making exposures of arms, legs, etc., as shown in Fig. 2616*t* £3 0 0

No. 2616*st.* Similar Table, arranged so that stereoscopic exposures can be made (suggested by Dr. Claude Gouldesbrough) £8 10 0



No. 2616 Arranged to use the Tube below a Couch.

Our Tube Stand No. 2116 has been supplied amongst others to:—

Charing Cross Hospital; National Hospital (Queen's Square); St. Bartholomew's Hospital; St. George's Hospital; Victoria Hospital for Children, Chelsea.

Essex County Hospital; General Hospital, Bristol; Grantham Hospital; The Infirmary, Bury; The Infirmary, Burton; Monkwearmouth and Southwick Hospital, Sunderland; North Staffordshire Infirmary; Royal Infirmary, Derby; Royal Infirmary, Liverpool; Royal Infirmary, Manchester; South Shields Union; General Infirmary, Chichester.

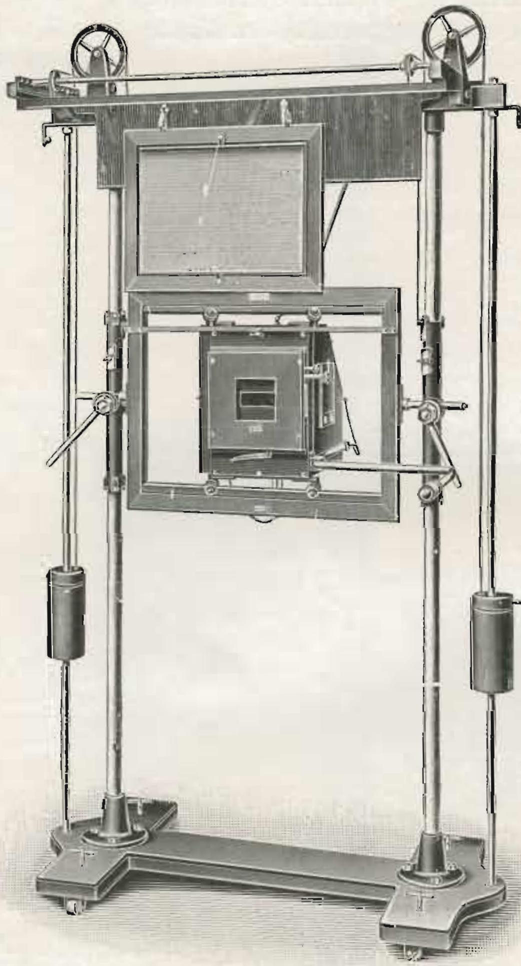
Cottage Hospital, St. Andrews; Royal Infirmary, Glasgow; The Infirmary, Wrexham.

British Hospital, Constantinople; The Hospital; Dunedin; Jeffrey Hale Hospital, Germiston; Wellington Hospital, New Zealand; Medical College, Lahore; Crown Agents for the Colonies.

C. M. Hinds Howell, D. F. Wright, C. Gouldesbrough.

P. J. S. Bird, Southsea; R. H. Dix, Sunderland; H. E. Gamlen, West Hartlepool; Hutchinson, Worthinghton & Mead, Lowestoft; C. B. Kempe, Salisbury; L. C. Panting, Truro; F. W. Taylor, Blackburn.

A. F. Cole, Ningpo; H. C. Highet, Bangkok; C. P. Jordan, Hong-Kong; N. C. Munro, Yokohama.



No. 2617.

No. 2617. **Beclere's Stand,** Fig. 2617 including box, to prevent the escape of X rays and green light **£30 0 0**

Arrangement that *stereoscopic* pictures can be taken also with the cylinder diaphragm, extra **£3 6 0**

Pneumatic Cushion extra **1 12 0**

This is the most complete and universal stand existing. It can be used above or below the couch for taking photographs, is provided with flat, adjustable diaphragm, and with a cylinder diaphragm, can be used for ordinary or for stereoscopic exposures. (The arrangement for taking stereoscopic pictures with the *flat* diaphragm is included in the price; if stereoscopic pictures are desired also with the *cylinder diaphragm*, a special addition is necessary.)

It can be used equally well for examination on the screen, or for therapeutic purposes. The fluorescent screen can be suspended at any height, and a black curtain can be drawn in front of the tube.

The tube is completely enclosed in a box lined with X-ray proof rubber; neither X rays nor green light can reach the room, and operator and assistants are *thoroughly protected*, so that they require neither aprons nor spectacles. Owing to perfect mechanical construction, the friction is so small in our model of this stand, that the tube box can be moved up or down or sideways with the greatest ease with one hand only.

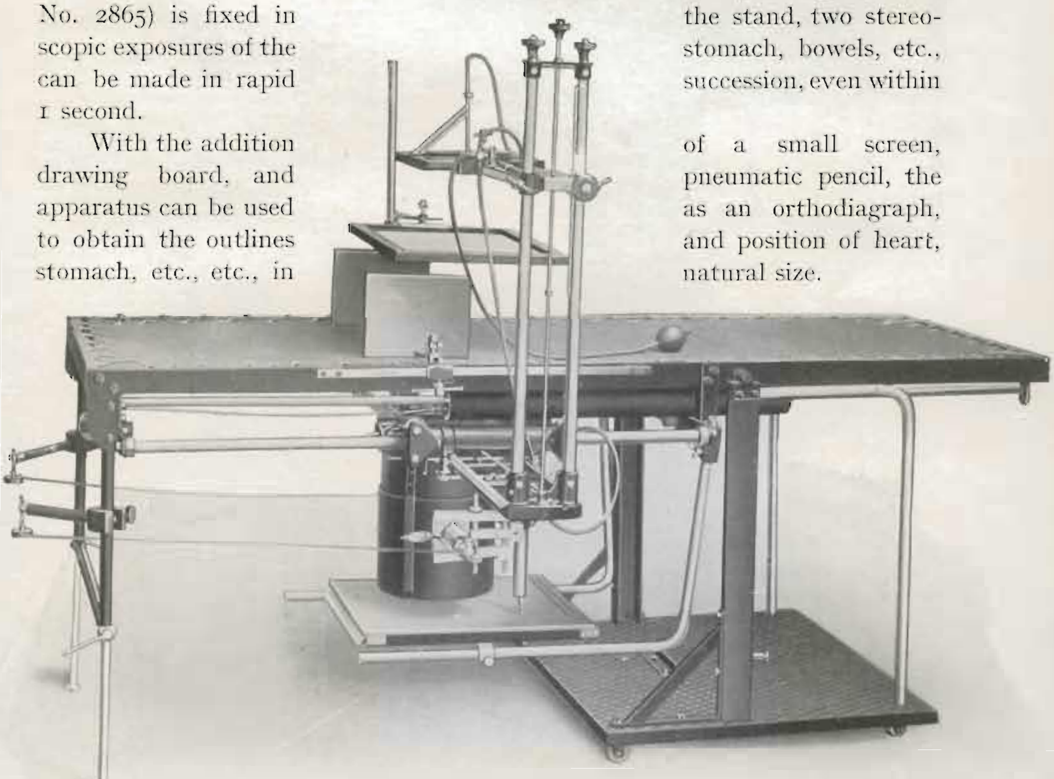
As supplied to Dr. Worrall, Mr. Coldwell, Dr. Ironside Bruce, London; Dr. Harris, Sydney; Stanley Hospital, Liverpool; Grimsby Hospital; General Hospital, Ramsgate; Infirmary, Warrington; Grant Medical College, Bombay; Royal Alexandra Hospital for Children, Sydney, etc., etc.

ORTHOSCOPE.

This Universal Tube Stand and Couch allows the patient to be examined in a horizontal or vertical position, standing or sitting, either on a fluorescent screen or by making exposures on photographic plates.

The cylinder enclosing the tube is opaque to X rays, and is provided with a rectangular and with an iris diaphragm; the aperture of these diaphragms can be adjusted by the operator while standing in front of the patient. They can be shifted so that the rays pass obliquely through the patient. The cylinder is fixed on a frame provided with ball bearings running on rails. The position of the tube can be adjusted easily, so that the central rays pass through the parts we wish to examine. Tube and screen are connected so that they move together, and when an exposure on a photographic plate has to be made, the tube holder can be fixed by turning a lever, the screen is removed, and the cassette with the plate slipped in instead. The tube can be moved to the right or left a certain distance to obtain negatives for the stereoscope. If a suitable cassette, allowing the plates to be changed rapidly (see No. 2865) is fixed in the stand, two stereoscopic exposures of the stomach, bowels, etc., can be made in rapid succession, even within 1 second.

With the addition of a small screen, drawing board, and pneumatic pencil, the apparatus can be used as an orthodiagraph, to obtain the outlines and position of heart, stomach, etc., etc., in natural size.



No. 2620.

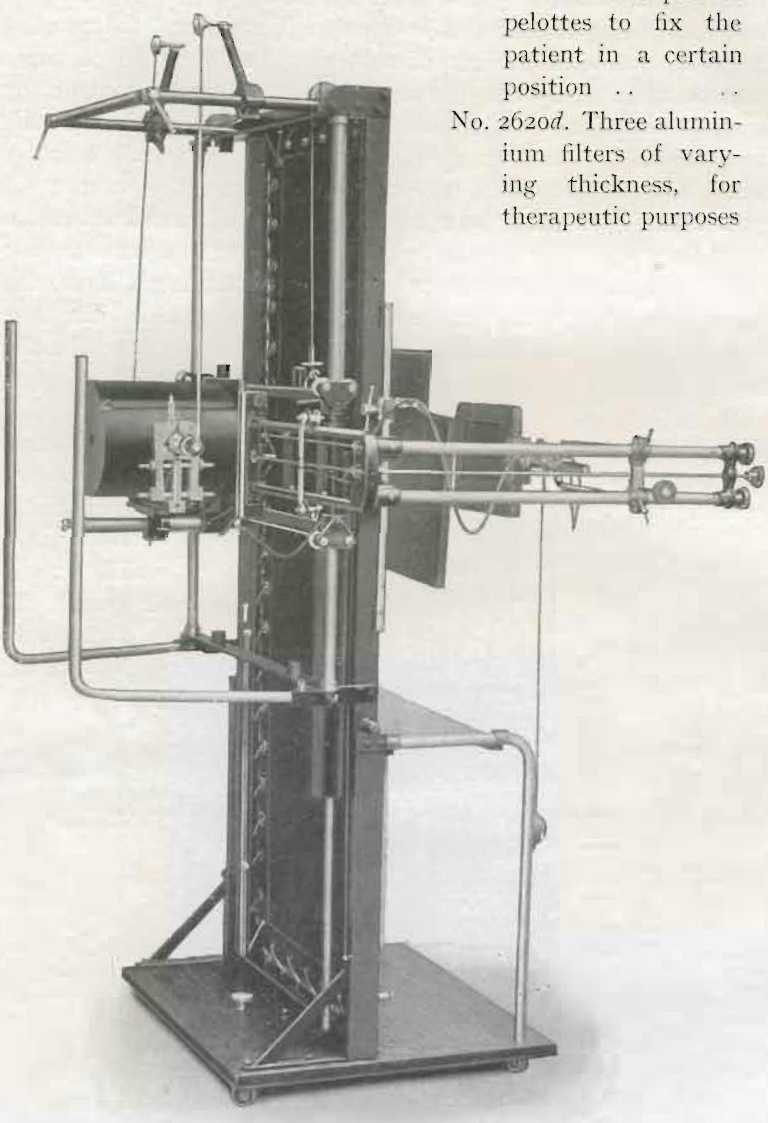
No. 2620. **Orthoscope,** Figs. 2620 and 2620*a* . **£72 0 0**

The following accessories can be added :—

No. 2620*s*. Fluorescent Screen 12 in. by 16 in., with lead glass plate, No. 2803, and frame for cassette .. £11 0 0

No. 2620*e*. One pair of pelottes to fix the patient in a certain position 1 0 0

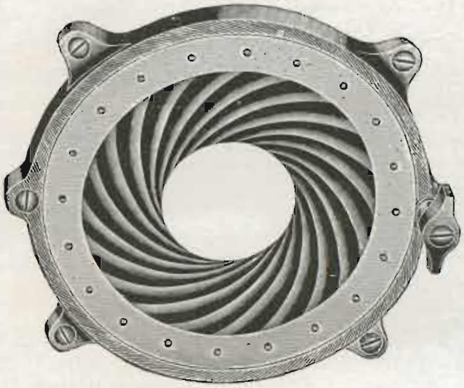
No. 2620*d*. Three aluminium filters of varying thickness, for therapeutic purposes 0 8 0



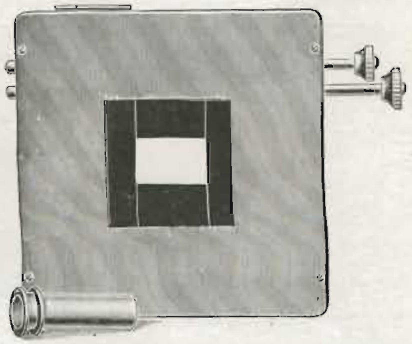
No 2620*a*.

No. 2620*c*. Arrangement to use the orthoscope as an orthodiagraph, to trace the outlines and position of heart, stomach, etc., in natural size .. 11 0 0

As supplied to The Radium Institute, Westminster Hospital; Sir David Salomons; Lieut.-Colonel Drake Brockman, Dr. Judah, Bombay, etc., etc.



No. 2627.



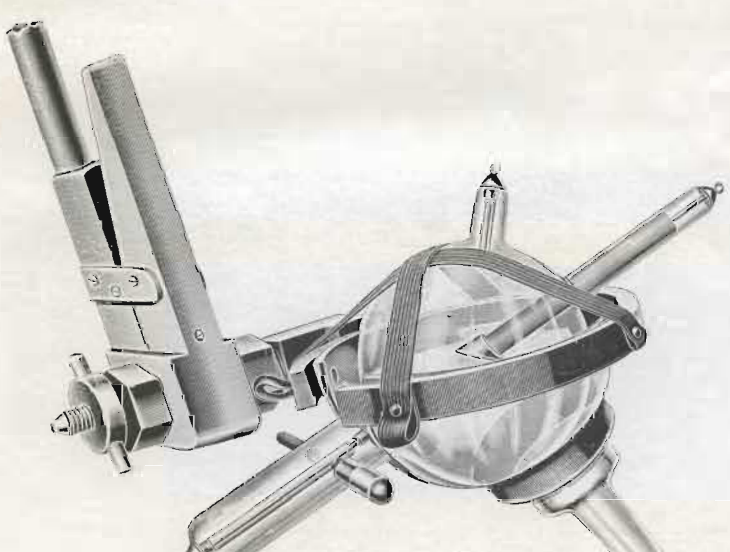
No. 2628.

No. 2627. **Iris Diaphragm** for X rays, Fig. 2627 .. .. £1 18 0

This diaphragm can be used with Stands Nos. 2612, 2616 and 2617. If the iris diaphragm is chosen to replace the adjustable rectangular diaphragm, the prices quoted for the Stands Nos. 2616 and 2617 will be *reduced* by 20s.

No. 2628. **Rectangular Diaphragm** (Fig. 2628) £2 15 0

The size of the rectangular opening can be varied by means of the two projecting screws. This diaphragm is supplied with, and included in the prices of, Stands Nos. 2616 and 2617.

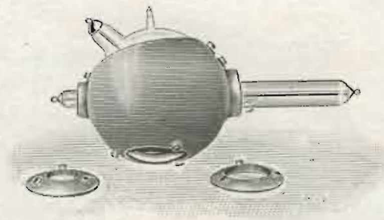


No. 2630.

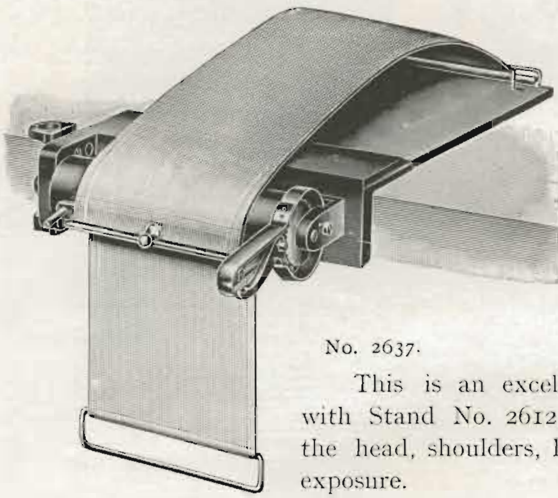
No. 2630. **Dr. Kienboeck's Diaphragm** of lead glass, with clamp fitting into Stand No. 2611, Fig. 2630 .. .. £4 4 0

No. 2634. Dr. Kaiser's **India-Rubber Diaphragm,** with 2 exchangeable discs, with apertures 4 and 6 ctm. wide.

A. For tubes $5\frac{1}{2}$ ins. diam. ..	**£1**	**1**	**0**
C. For tubes $6\frac{1}{2}$ ins. diam. ..	**1**	**7**	**0**
E. For tubes 8 ins. diam. ..	**1**	**12**	**0**



No. 2634.



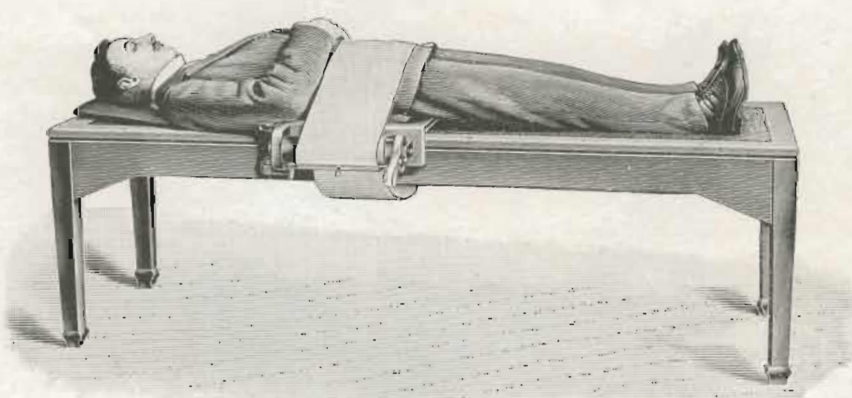
No. 2637.

No. 2637.

Compressor, consisting of stout canvas band to be stretched across the patient, with clamp to fix it, Fig. 2637 .. **£4 15 0**

This is an excellent compressor, to be used with Stand No. 2612, for the kidneys, or to keep the head, shoulders, knees, etc., steady during the exposure.

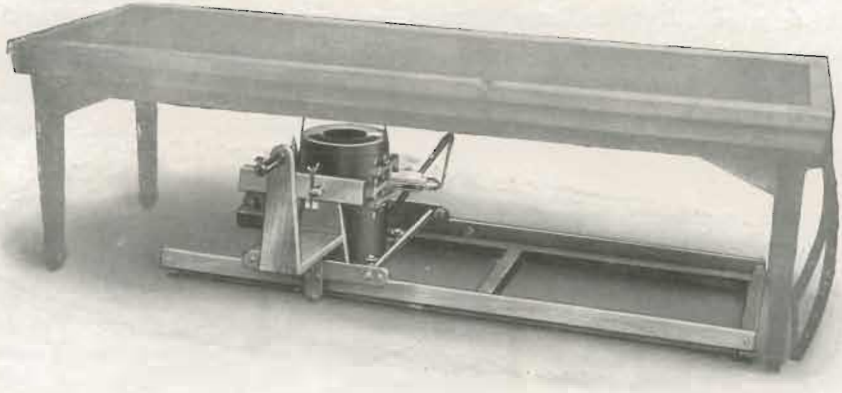
COUCHES.



No. 2650.

No. 2650. **Plain Table,** with cover of 3-ply wood **£4 0 0**

No. 2651. **Table,** with cover, and in addition with a felt-covered plate, which can be raised at the head end, or can be removed entirely if the tube is to be used below the couch **£7 10 0**



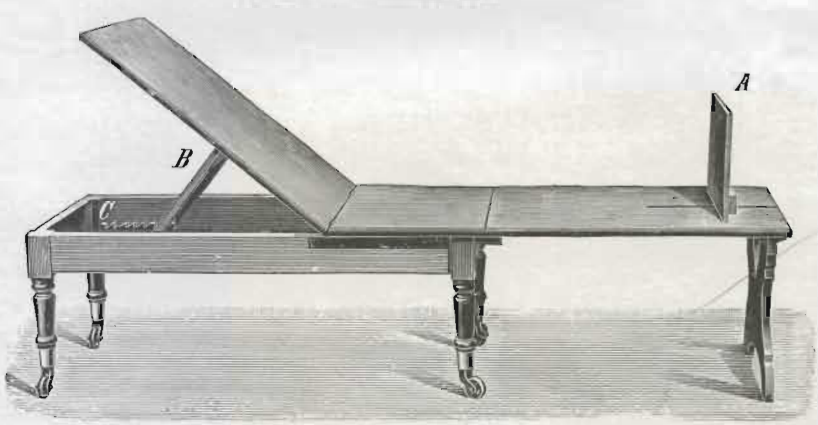
No. 2653*b*.

The Frame with the tube holder below couch, shown in illustration, is not included in this price.

No. 2653*b*. **Frame,** with tube holder to fit under the couch, as shown in Fig. 2653*b*. Tube is enclosed in box lined with X-ray-proof rubber. There is an arrangement by which the position of the tube can be conveniently adjusted.. .. .. **£8 15 0**

The frame carrying the tube holder can be arranged so that it is suspended between the four legs of the table, instead of resting on the floor as shown in illustration. The price will be the same.

No. 2653*c*. **Couch,** Fig. 2653*b*, complete, with frame, tube holder, and box to enclose tube **£16 10 0**



No. 2655.

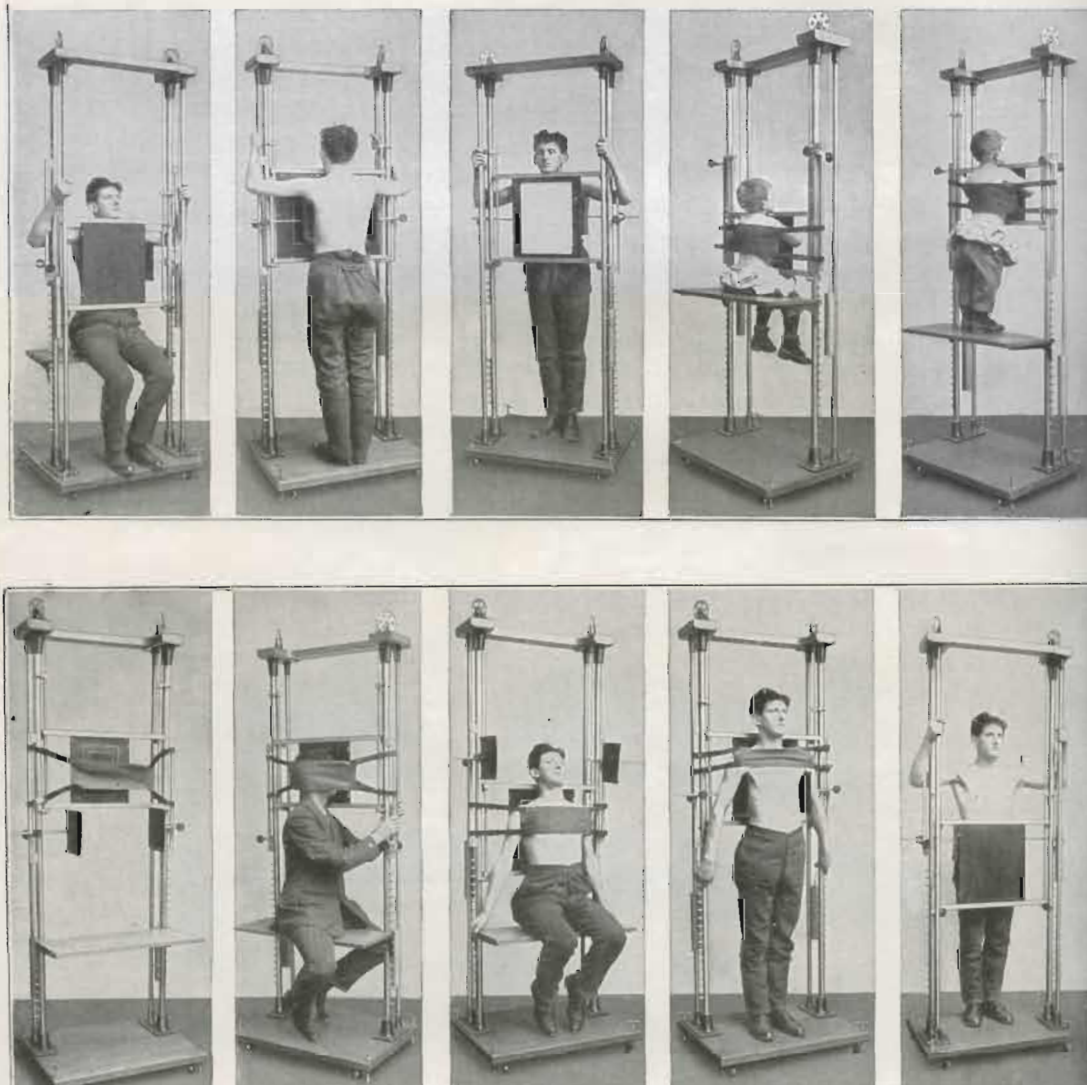
No. 2655. **Folding Couch,** Fig. 2655 .. .. .. **£6 6 0**

This X-ray couch is very convenient when the available space is small. It is 24 in. wide, 20 in. high, and 79 in. long: when folded up it is only 49 in. long. It is provided with an adjustable foot rest, and the part for the head can be raised or lowered.

No. 2659. **Dr. Ironside Bruce's Couch,** latest model, 1912 .. **£22 0 0**

This is an excellent couch. We made the model with the latest modifications to the order of Dr. Ironside Bruce.

Illustrations and Prices of the Haenisch, Gilmer, etc., couches can be had on application.



No. 2662.

No. 2662. **Dr. Kienboeck's Upright Frame,** to make exposures or examinations with the patient standing or sitting, Fig. 2662 .. .. **£12 0 0**

This stand is very convenient for making exposures of the head, thorax, and abdomen. The patient can be fixed with adjustable pelottes, and the cassettes holding the plates can be adjusted at the correct height.

No. 2664. Similar **Stand,** but simpler model, Fig. 2664 **£4 12 0**

No. 2667.

No. 2667. **Adjustable Desk** for holding the cassette for X-ray exposures, Fig. 2667 **£9 5 0**

The illustrations show a few of the many ways in which this desk can be used. It is very convenient for many consulting rooms in which space is limited.

SWITCHBOARDS,

to control the Current from the Main.

MOTOR TRANSFORMERS, ENGINES, DYNAMOS.

(See also page 185.)

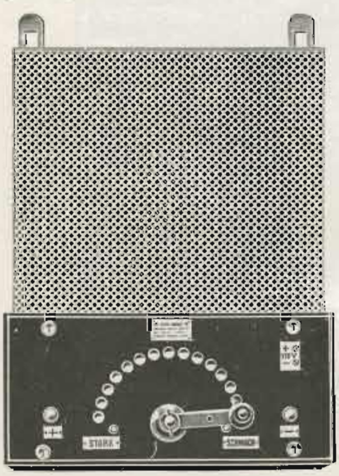
Accumulators suitable for Spark Coils will be found on page 88.

Bichromate Batteries for Spark Coils will be found on page 89.

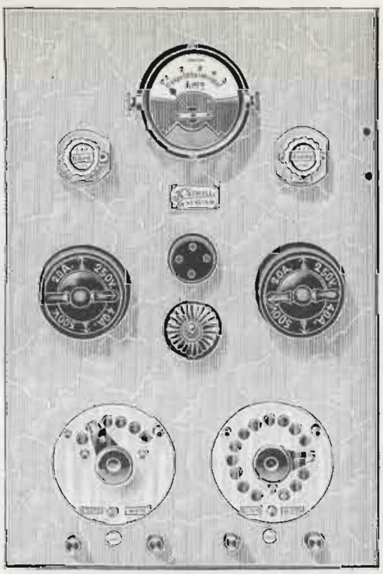
Switchboards are made in great variety, to suit the individual requirements. On the following pages are described and illustrated the types which are most frequently used, but *other combinations can be made within a few days.*

The *first* switchboards ever made for utilizing the current from dynamos for medical or surgical purposes were designed and made by us in our workshop in London in 1890. Since that time we have made over 2000 switchboards; amongst this number are several hundreds made for X-ray purposes.

We have therefore the longest and *by far the largest experience* in this work, and this enables us to supply the *best quality obtainable.*



No. 2672.



No. 2674.

No. 2672. **Series Rheostat,** *Fig.* 2672, to control the primary current for a spark coil.

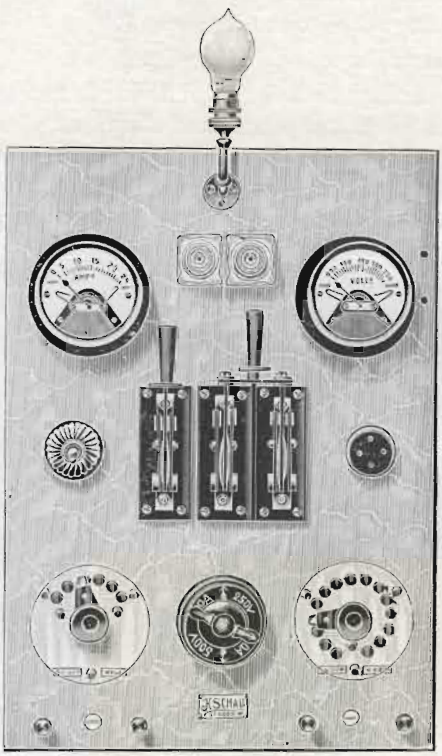
A, for 12 to 30 volt (accumulators)	B, for 100 volt currents	C, for 200 to 250 volt currents
£2 10 0	£3 12 0	£6 0 0

No. 2674. **Series Rheostat** for spark coils, on slate or marble, with switch, fuse, ampèremeter, current reverser, and rheostat to control speed of mercury break, Fig. 2674.

A, for 12 to 30 volts	B, for 100 volts	C, for 200 to 250 volts
£7 15 0	£10 0 0	£12 0 0

IMPROVED SWITCHBOARDS.

Allowing the spark coils to be used in a "shunt" or "in series," at the will of the operator (see page 185).



No. 2675.

No. 2675*a*.

No. 2675. **Switchboard,** Fig. 2675 .. .. .. **£17 0 0**

This Switchboard can be used as *Series* rheostat for *instantaneous or tele exposures*, or as *Shunt* rheostat for *time exposures, examination on the screen*, or for *therapeutic purposes.*

Sir James Mackenzie Davidson wrote us the following letter about the Shunt Rheostat No. 2675:—

Dear Mr. Schall, March 27th, 1899.

I am very pleased with your volt selector. I tried it with the new interrupter with most excellent results.

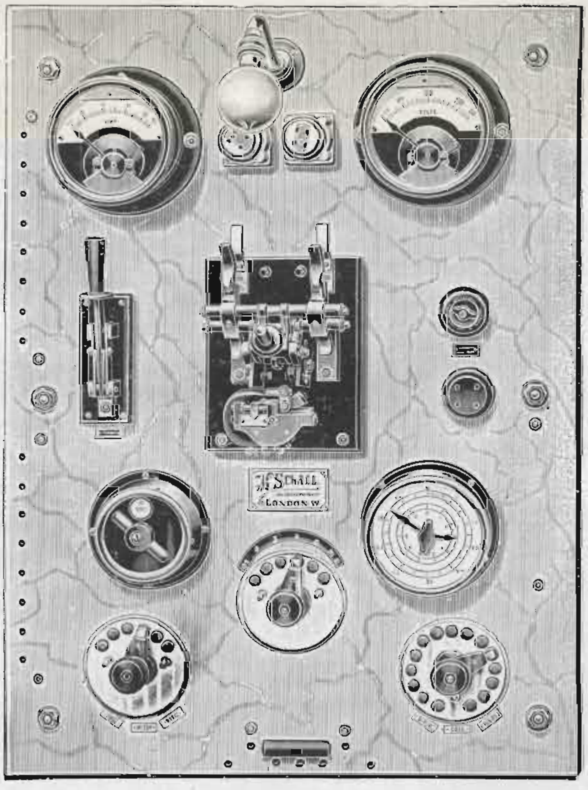
Yours sincerely,

J. Mackenzie Davidson.

On an enamelled slate or polished white marble slab are mounted: volt and ammeter, double-pole and single-pole switch, variable resistance for the spark coil, switch and variable resistance for the motor of the mercury interrupter; signal lamp, fuses, and terminals.

The pegs of the rheostat are protected by glass plate discs, and the terminals are insulated, to prevent upleasant shocks by handling the switchboards in darkness. Size: 16 in. wide, 23 in. high.

The various switchboards can also be arranged on tables or trolleys of enamelled steel, as shown in Fig. 2675*a*. In many cases this is more convenient than the switchboards fixed in the wall, because the trolleys can be moved about and placed in such a position that the operator can watch the tube, milliampèremeter, and patient while handling the switchboard; whereas when the latter is fixed on the wall, he may have to turn his back occasionally to the tube while handling the rheostat. Another decided advantage is that there is no need to make any holes in the walls to fix the switchboards.



No. 2678.

No. 2677. **Large Switchboard,** provided with: a variable

Series Rheostat, for instantaneous or tele exposures; and a variable

Shunt Rheostat, to vary the voltage from the main gradually from 40 up to about 140 volts, for time exposures, examination on the screen, or for therapeutic purposes;

Automatic Double Pole Switch and Clock Work, which can be adjusted so that the primary current is broken automatically after a previously arranged time, which can be set at any fraction of a second, from $\frac{1}{20}$, $\frac{1}{10}$, $\frac{2}{10}$, etc., to 10 seconds.

Dead Beat Volt and Ammeter;

Switch and Rheostat, to control the motor of the mercury interrupter, signal lamp, fuses and terminals.

£27 0 0

The pegs of the rheostats are protected by glass covers, and the terminals are insulated with ebonite, to prevent unpleasant shocks while handling the switchboard in darkness. The switchboard is similar to *Fig.* 2678. Size, 24 in. wide, 34 in. high.

No. 2678. Similar **Switchboard,** but provided in addition with a switch to insert either a mercury, or an electrolytic break; to use the anodes of the latter either separately, or connected parallel, and with a commutator to insert four different degrees of self-induction of the primary coil, *Fig.* 2678 .. **£33 0 0**

This Switchboard can also be arranged on a trolley, as shown in *Fig.* 2675*a*.

Our Larger Switchboards have been supplied, amongst others, to:—

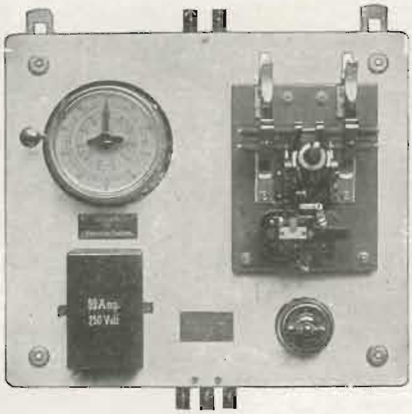
Dr. Ironside Bruce, Dr. E. S. Worrall, Mr. Coldwell, Sir D. Salomons, Dr. Dix (Sunderland).

Grimsby Hospital; Stanley Hospital, Liverpool; General Infirmary, Chichester; Infirmary, Warrington; South Shields Union Infirmary. The Hospital, Dunedin; Royal Prince Alfred Hospital, Sydney; St. Margaret's Hospital, Launceston; Royal Alexandra Hospital for Children, Sydney.

Dr. Harris, Sydney; Dr. Judah, Bombay; Dr. G. Murchison, Auckland; Lt.-Colonel Drake Brockman.

No. 2679. Separate **Switchboard,** with automatic double pole switch and clock work, which can be adjusted so that the primary current is broken automatically after a previously arranged time, which can be set at any fraction of a second from $\frac{1}{10}$, $\frac{2}{10}$, etc., up to 10 seconds, Fig. 2679 .. **£12 15 0**

This switchboard can be connected in series with other existing switchboards.



No. 2679.

Estimates for other types of Switchboards will be sent on application. We can make almost any combination in our workshop in London within one week.

[*Copy of an unsolicited testimonial.*]

SYDNEY, *Jan. 28th,* 1911.

The switchboard (No. 2678) is a dream, the finest piece of work I have ever seen.

DR. HARRIS.

No. 2679*a*. **Foot Switch,** on cast-iron base, Fig. 2679*a*, to turn the primary current on or off **£3 5 0**

No. 2679*a*.

MOTOR TRANSFORMERS, to convert an ALTERNATING into a CONTINUOUS CURRENT.

The Motor Transformers described below consist of alternating current motors which are coupled to continuous current dynamos, and both are fixed on a strong plate of cast iron. The dynamos used are constructed specially for X-ray purposes; there is no risk of the insulation of the dynamo being damaged by the electric waves set up in the primary current of the spark coils, and the dynamos can give *double the normal output* for the short time required for X-ray exposures without risk of any damage.

For spark coils with mercury interrupters it is sufficient if the dynamos can supply 1000 to 1200 watts. If an electrolytic interrupter is to be used, the dynamo should be capable of giving 2000 watts. The latter size can also be used for Finsen lamps, Haab magnets, Quarz mercury lamps, etc.

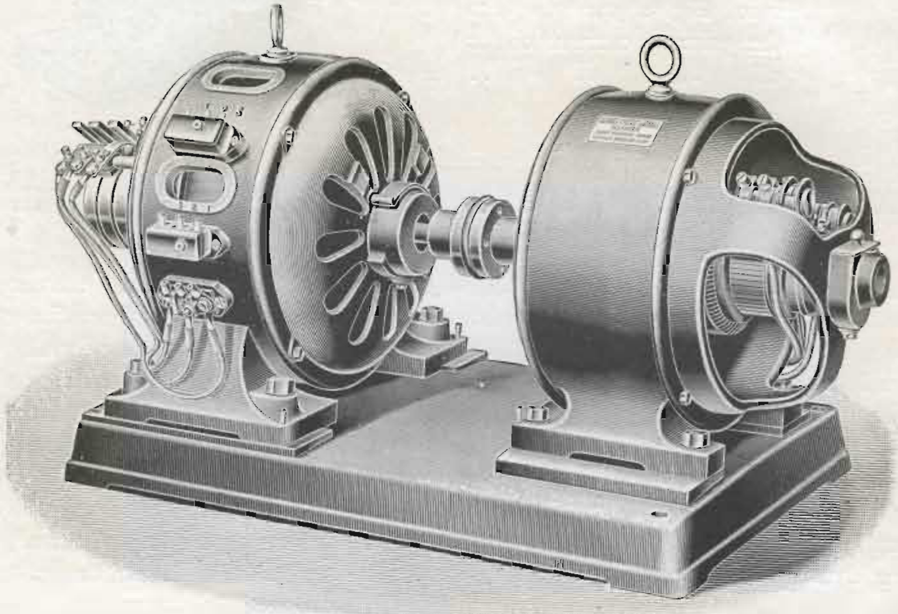
The starting of the motor transformers is extremely simple, the lever on the rheostat has to be turned from left to right. The spark coil can then be switched on, and the current from the dynamo for coil and interrupter is controlled in the usual manner by the switchboard supplied with the coil. A well-constructed motor transformer, fixed on a strong bed-plate, makes only a low humming noise, but a hollow resounding floor should be avoided. If there should be unusually sensitive neighbours, any vibration or noise can be stopped efficiently by fixing below the cast-iron bed-plate two wooden boards, and placing between them a piece of soft felt ½ inch to 1 inch thick. The transformer can be fixed in the X-ray or another room, or in a basement. There is nothing breakable or requiring renewal, and although many are in daily use, some of them for twelve years, there have been no repairs necessary up to now, and no complaints have been made, which is a proof of their reliability and simplicity in working.

The *Cooper-Hewitt Mercury Vapour Lamps* might also be used for converting alternating into continuous currents. Although they rectify as well as the motor transformers, we do not consider them to be as good in the long run on account of the wear and tear and the fragile nature of the lamps. Mercury is contained in exhausted glass tubes, there is obviously great risk in transit, as quick tilting of a box causes the mercury to smash the lamp. When once safely installed, the lamps wear out gradually. They have usually a fairly long lifetime, up to 1,000 hours, but after this they have to be replaced; a new lamp costs £5, and there is again the risk in transit.

Though the original cost of £35 (without a spare lamp) is a little less than the cost of a motor transformer, the mercury vapour lamps are sure to be more expensive in the long run, and they are in no way easier to start and work than the motor transformers.

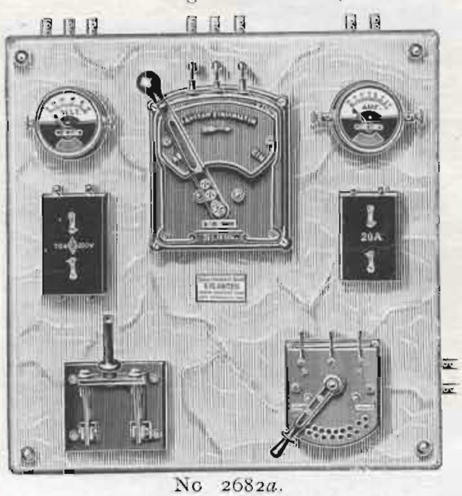
No. 2680. **Motor Transformer,** consisting of an alternating current motor and a continuous current dynamo, **including** shunt rheostat for dynamo and starter for the transformer, for 40 to 60 periods .. **£40 0 0**

The dynamo is of 1 H.P. size, but it is so wound that it will give a continuous current of 110 *volts with* 10 *ampères for short periods, not exceeding* 10 *minutes at a time, without any fear of damage.*



No 2682

No. 2682. **Motor Transformer,** consisting of an alternating current motor and a continuous current dynamo, mounted on cast-iron plate. The latter supplies a current of about 1100 watts (for instance, 10 ampères and 110 volts), or, for a period not exceeding 10 minutes, 2200 watts, Fig. 2682 .. .. **£46 0 0**



No 2682*a*.

No. 2682*a*. **Switchboard,** provided with double-pole switch, starting resistance, regulating resistance, fuses and terminals, Fig. 2682*a* **£10 0 0**

No. 2684. Similar **Motor Transformer,** but larger size, continuous current dynamo supplies 60 ampères and 110 volts **£80 0 0**

No. 2684*a*. **Switchboard,** for this size transformer .. **£11 0 0**

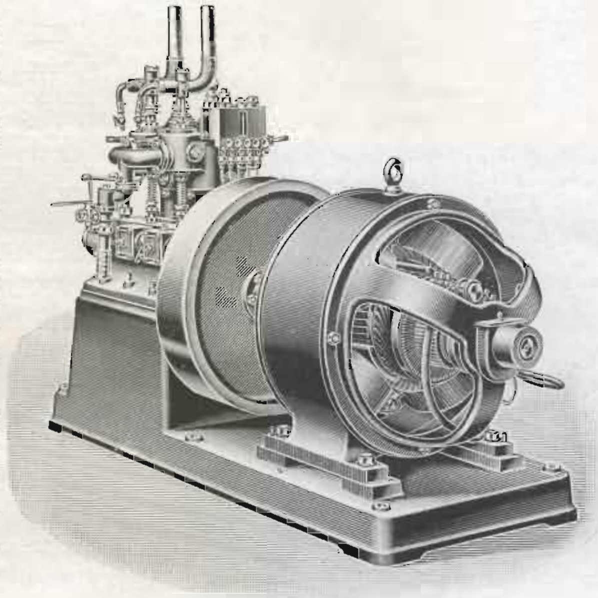
Estimates for other sizes will be sent on application.

ENGINE WITH DYNAMO.

For producing the currents for Röntgen rays, high-frequency currents, arc lamps for treating lupus, and for illuminating small hospitals, etc.

No. 2691. 1 H.P. **Engine** with heavy flywheel and dynamo, complete, Fig. 2691 .. **£68 0 0**

The dynamo gives a current of about 500 watts. It can also be used for supplying the current for about forty 16 candle-power lamps.



No. 2691.

No. 2693. **Similar Engine and Dynamo,** but larger size, 3·5 H.P., complete with tank, tubes, etc. **£95 0 0**

The dynamo supplies 110 volts with 20 to 25 ampères.

Estimates for larger engines and dynamos can be had on application.

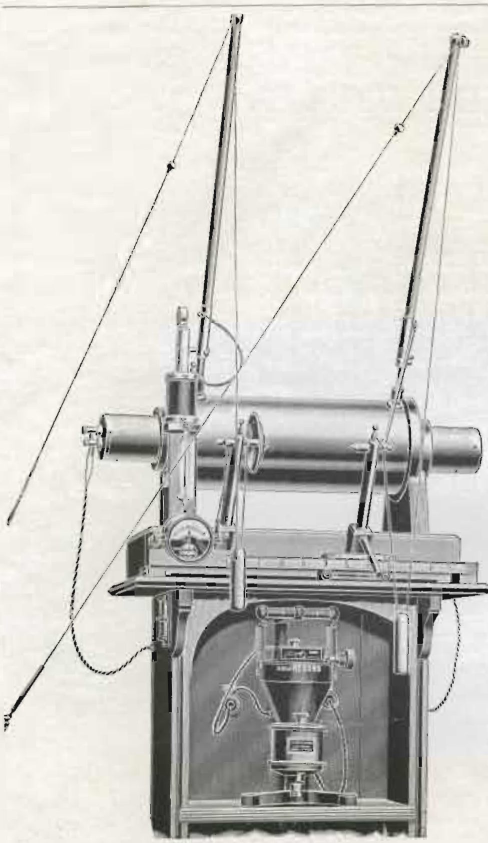
The dynamos are shunt wound, and can therefore be used for charging accumulators; in this case a larger number of incandescent lamps can be used.

The engines make about 800 revolutions per minute. They are easily started, and require little attention for cleaning, etc.

The engines can be used with methylated spirit, benzine, or petrol. They require 24 ozs. of spirit, or 16 ozs. of benzine, or 18 ozs. of petrol per H.P. in one hour, and are therefore cheap to work (less than 2d. per hour).

The size is: Total height, 27 inches; width, 14 inches; length, 16 inches; diameter of the flywheels, 16 inches; weight, complete, 1½ cwt.

We have supplied these engines amongst others to: The Government of India, for the Agra Medical School; the Crown Agents for the Colonies; for Maseru Hospital, Basutoland; Major Sunder, Pilgrim Hospital, Gaya; Dr. Ingram, Teneriffe; Dr. Topalian, Diabekir; Civil Dispensary, Kasur, India; etc., etc.



INSTRUMENTS TO MEASURE X-RAYS.

(*See also pages* 199-202.)

The illustration shows a convenient combination of measuring instruments:

A Spark Gap, with scale, to measure either the equivalent spark length, or else the number of milliampères which can be obtained through an air gap,

A Milliampèremeter for X rays,

An Oscilloscope Tube, and

A Spark Gap, No. 2600, to suppress the reverse current, are arranged on the cabinet on which the spark coil and interrupter are placed.

A pair of wooden masts carry the secondary wires leading to the tube safely over the head of the operator, and running weights keep these wires stretched.

MILLIAMPÈREMETERS OF THE D'ARSONVAL TYPE,

to Measure the Current passing through X-Ray Tubes.

(*See also pages* 200-202.

No 2722.

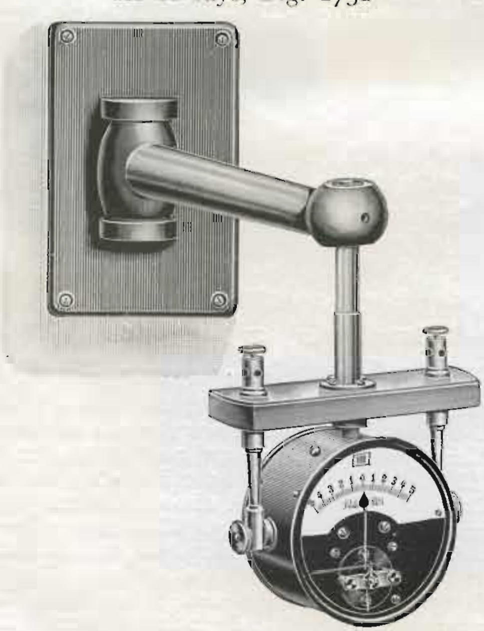
No. 2730.

These instruments are provided with a condenser, are dead beat, and can be used in any position. Diameter $4\frac{1}{4}$ ins.

No. 2720.	**Milliamperemeter,** indicating, up to 5 M.A., every tenth part of a milliampère	**£3 3 0**
No. 2721.	Similar instrument, provided with a shunt, reading up to 5 or up to 50 M.A.	**3 7 0**
No. 2722.	Similar instrument, with 2 shunts, reading up to 3, 30, or 300 M.A., Fig. 2722	**3 12 0**

Similar instruments, but with a diameter of $6\frac{1}{2}$ ins. Reading one way only. The advantage of this is that the divisions are much larger, so that small fractions can be measured, and the indications of the instrument are plainly visible *at a greater distance.*

No. 2724.	Large **Milliamperemeter,** for X rays, indicating up to 3, 15 or 30 M.A.	**£4 10 0**
No. 2725.	Large **Milliamperemeter** for X rays, indicating up to 5, 25 or 50 M.A.	**4 10 0**
No. 2726.	Large **Milliamperemeter** for X rays, indicating up to 5, 20 or 100 M.A.	**4 10 0**
No. 2730.	Small board, fitting Stands Nos. 2610 to 2612, with terminals to carry the M.A. Meters Nos. 2720–2722, Fig. 2730	**0 9 0**
No. 2731.	Similar board, for the milliampèremeters of large diameter, Nos. 2724–26	**0 12 6**
No. 2732.	Bracket, with terminals, to suspend M.A. meters for X rays, Fig. 2732	**1 0 0**



No. 2732.

No 2733.

No. 2733. Porcelain column with terminals, to suspend M.A. meters for X rays, Fig. 2733 .. .. £1 2 0

No. 2735.

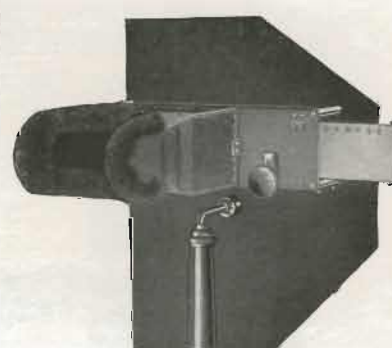
No. 2735. Dr. Wehnelt's small Radiometer, Fig. 2735 .. .. .. £0 10 0

(*See pages* 189-190.)

This is a modification of the Radiometer of Benoist. A parallel silver strip and a wedge-shaped piece of aluminium (7 inches long) are mounted side by side, and can be moved by means of a rack and pinion behind a narrow strip of a fluorescent screen, so that the lower half of the screen is covered by silver of uniform thickness, the upper half by aluminium of variable thickness.

The luminosity of the field covered by the silver remains uniform, and is used for comparison, like the light of a standard candle. The luminosity of the part of the screen covered by the aluminium changes according to the condition of the tube and the thickness of the aluminium.

No. 2736.



No. 2738.

No. 2736. **Dr. Wehnelt's Crypto-Radiometer,** Fig. 2736 .. £2 15 0

No. 2738. **Dr. Christen's Radiometer,** Fig. 2738 .. .. 4 0 0

Dr. Christen has suggested that the penetrating power of X rays should be measured in terms of the depth of distilled water, which absorbs just half the dose which has been given to the surface. Soft rays are more readily absorbed than hard ones, and therefore this depth of distilled water is much less for the former than for the latter. Moreover, distilled water possesses almost the same opacity toward X rays as the flesh and tissues of the human body. The depth referred to above can therefore easily be taken as the depth of tissue which is capable of reducing the effect of the rays to one-half.

The Christen Penetrometer is constructed on the same principle as that of Wehnelt. But instead of a silver strip, we have a lead grating—so made that it lets one half the radiation through, and instead of the aluminium wedge there is a

ladder of varying thicknesses of a substance having the same opacity to the rays as distilled water.

This ladder is moved past the grating till the patches of light which each produces on the fluorescent screen are equal in intensity. A scale mark then gives the depth at which the rays are half absorbed for the particular tube.

No. 2740.

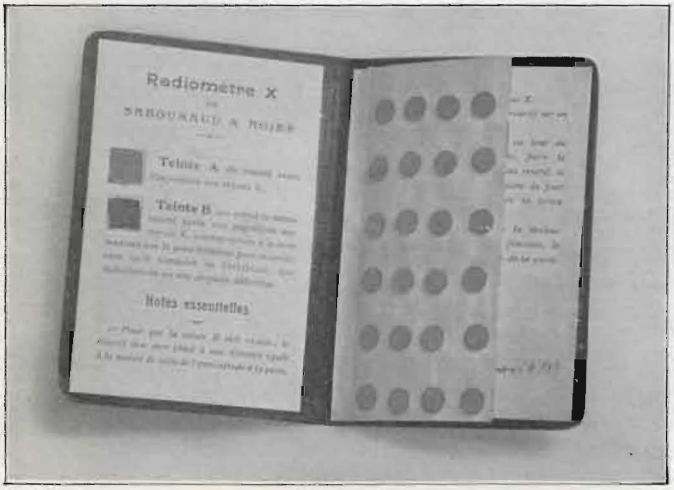
No. 2740. **Bauer's Qualimeter,** Fig. 2740 **£7 0 0**

This instrument is a static voltmeter. When the index points to 2, this means that the penetrating power of the rays is such that they will be absorbed or stopped by a sheet of lead 0·2 mm. thick. When the index points to 5, the tube gives harder rays, and lead 0·5 mm. thick is required to stop the rays.

The qualimeter remains connected with the *cathode* of the tube during the exposure. Its advantage is that the operator has not to test any more at intervals, with a radiometer, whether the penetrating power of the tube remains correct or whether it has changed. He can see at a distance, merely by looking at the index of this instrument, what hardness the rays have.

The following table shows how the indications of the Bauer qualimeter compare with other radiometers :—

	Soft.		Medium				Hard.			
Bauer ..	1	2	3	4	5	6	7	8	9	10
Wehnelt ..	1·5	3	4·5	6	7·5	9	10·5	11	13·5	15
Benoist ..	1	2	3	4	5	6	7	8	9	10



No. 2743.

No. 2743. **Sabouraud's Booklet,** with 24 pastilles, Fig. 2743 .. **£0 13 9**

The pastilles are to be exposed on a metallic support, at *half* the distance existing between anticathode and skin (see No. 2614).

No. 2745.

No. 2745. **Dr. Bordier's New Chromo-Radiometer,** Standard Scale, in frame, with 6 different tints, Fig. 2745 **£1 1 0**

No. 2746. 100 Pastilles for Dr. Bordier's scale **1 1 0**

This new Chromo-Radiometer depends, as Sabouraud's, on the discoloration of pastilles of barium platinocyanide, but the scale shows five different tints for comparison, instead of the single one of Sabouraud's instrument. Bordier's pastilles have to be attached *to the skin* of the patient. Directions for use will be sent with them.

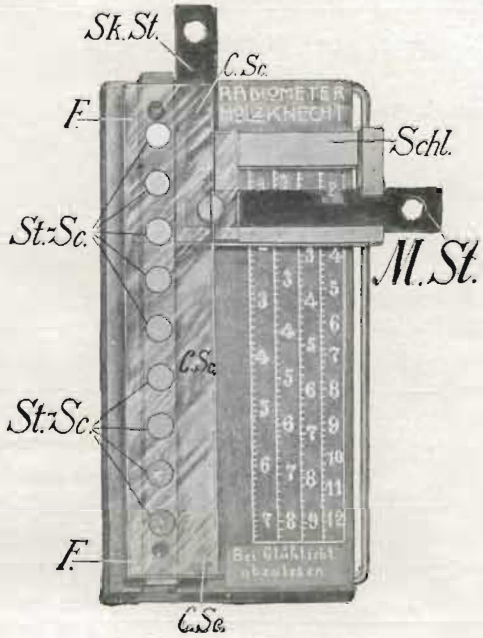
The pastilles should be compared with the scale or "Teinte B" by the light of a match, a candle, a benzine lamp, or other artificial light of slight actinic power.

The distance between the pastilles and the glass wall of the tube should never be less than 2 ctm, to prevent their being discoloured by the heat of the tube.

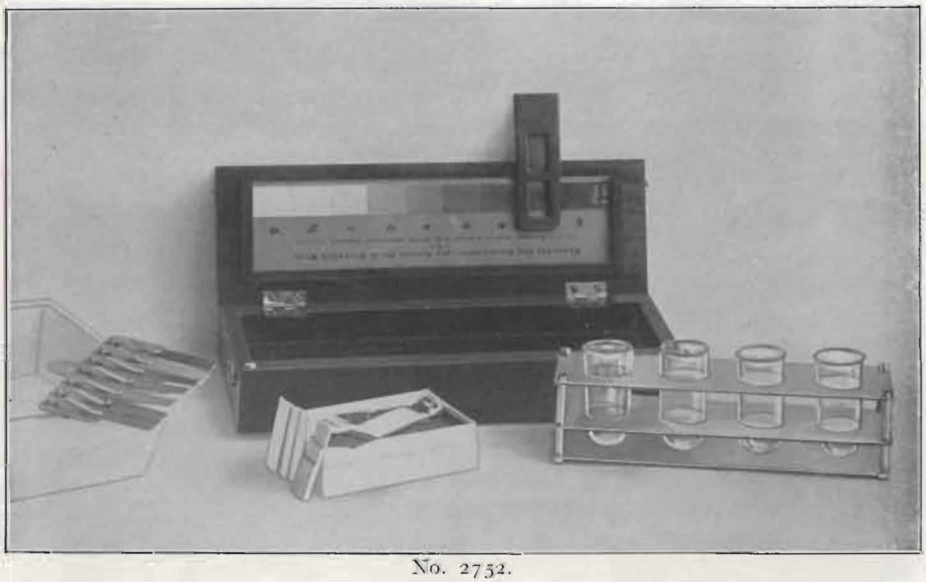
The pastilles are most accurate while used with tubes of medium penetrating power. With soft tubes they tend to indicate a smaller dose, with hard tubes a larger dose than actually given.

No. 2748. **Holzknecht's new Quantimeter,** Fig. 2748, including carrier for the exposed pastilles **£3 16 0**

For this instrument, barium platino-cyanide pastilles are also used, but they are compared with unexposed pastilles of the same material, arranged under a celluloid film of red-brown colour, increasing gradually in intensity. By moving the exposed pastilles along this film, the discoloration caused by ½, ¾, etc., of an erythema dose can be measured.



No. 2748.



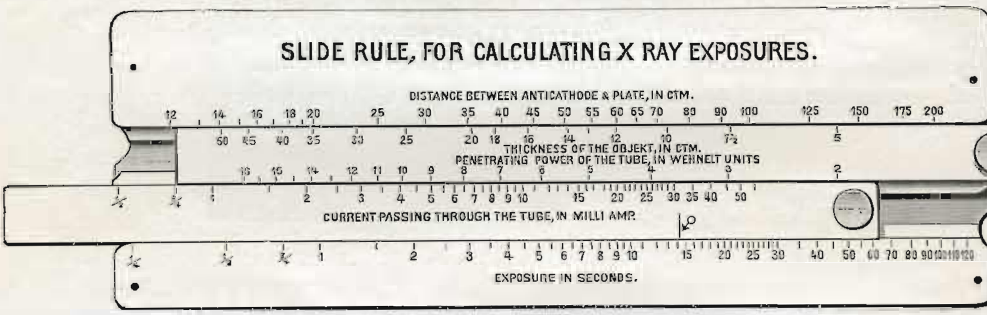
No. 2752.

Dr. Kienboeck's Quantimeter.—This is the most sensitive and the most accurate method of measuring the quantity of X rays existing up to now. Full description and directions for use will be sent on application.

The instrument has been tested at the Blythswood Laboratory. The report made to the Röntgen Society says :—

" We must, therefore, come to the conclusion that although this instrument is open to the errors inseparable from the comparison of tints, it is a great improvement on others of its kind. We have no doubt that the scale is correct, and its ratio to others (Sabouraud, Holzknecht) is as stated."

No. 2752. Dr. Kienboeck's Standard Scale, Fig. 2752, in polished walnut box	£1 14 0
No. 2752*a*. Fifty strips of bromide of silver paper, in dark envelopes, with labels and numbers	0 9 6
No. 2752*b*. Stand, with four test tubes	0 9 6
No. 2752*d*. Three aluminium strips	0 2 6
No. 2752*e*. One aluminium strip, with three different degrees of thickness	0 2 6
No. 2752*r*. Dark box to develop the strips in daylight ..	1 16 0
No. 2752*n*. ½ litre developer A, ½ litre developer B, and 1 litre fixing solution, in glass-stoppered bottles ..	0 5 9



No. 2759.

No. 2759. **Slide Rule,** for finding the correct time for X-ray exposures, Fig. 2759	£0 11 0

Explanation of this convenient instrument will be found on page 208.

No. 2760.

No. 2762.

No. 2760. Clock, for measuring the duration of an exposure, Fig. 2760	0 10 0

If we wish to expose ½, 1, 2, 3, etc., minutes, the hand of the clock is set at the desired time, and the clock started when the exposure begins. It gives a gong signal after the previously set time has expired.

No. 2762. Clock, with switch *to interrupt* the primary current after a previously set time, Fig. 2762 .. **£1 2 0**

This clock gives a signal on the gong to remind the operator that the set time is over, and a few seconds afterwards it interrupts the primary current automatically. This is especially convenient when the X rays are used for therapeutic purposes.

A clock to interrupt the circuit automatically after $\frac{1}{10}$th, etc., of a second will be found under Nos. 2677 and 2679.

FLUORESCENT SCREENS AND ACCELERATING SCREENS.

FLUORESCENT SCREENS, for direct observation, coated with two thick layers of large crystals of barium platino-cyanide.

No. 2800.	5 × 7 in.	**£2 2 0**
No. 2801.	7 × 9½ in.	**3 6 0**
No. 2802.	9½ × 12 in., Fig. 2802	**5 5 0**
No. 2803.	12 × 16½ in.	**8 10 0**
No. 2804.	16 × 20 in.	**13 10 0**

The screens are the best quality obtainable.

At the time when this is being printed (July, 1913), the oz. of platinum costs three times as much as an oz. of gold, and the screens are therefore rather expensive at present. The price of platinum has fluctuated a good deal, and if it goes down again, the price will be reduced.

THE "ASTRAL" FLUORESCENT SCREENS.

These new screens give a light similar in colour to that of the platinum screens, but *brighter*; the image has *more contrasts*, so that more details become visible. The Astral screens do *not deteriorate* under the influence of the X rays, as the platinum screens do.

No. 2805.	Astral Screen, 7½ × 9½ in.	**£3 12 6**
No. 2806.	,, 9½ × 12 in.	**5 8 0**
No. 2807.	,, 12 × 16 in.	**8 12 0**
No. 2808.	,, 15½ × 20 in.	**14 2 0**

The prices quoted for the Astral screens *include* lead glass plates and protecting handles.

Plates of Lead Glass, to cover the screens, to protect the operator against the X rays passing through the screen.

No. 2815.	5 × 7 in.	7 × 9½ in.	9½ × 12 in.	12 × 15½ in.
	3/9	**4/9**	**7/6**	**10/–**

No. 2802, with handles. No. 2819.

No. 2817. **Metal Handles,** to be screwed on to the fluorescent screens, for the protection of the hands of the operator, shown in Fig. 2802 .. per pair **£0 5 0**

No. 2819. **Cryptoscope,** Fig. 2819, with Screen No. 2801 .. **4 6 0**

No. 2820

No. 2820. **Screen Holder,** for dental purposes, Fig. 2820 .. **1 2 6**

"GRAINLESS" INTENSIFYING OR ACCELERATING SCREEN FOR X-RAY NEGATIVES.

An important improvement has been made in Accelerating Screens. A new type has been invented, which enables us to obtain the finest details free from grain on the negative.

The time of exposure is reduced to between one-tenth and one-twentieth that which would be necessary without the use of such a screen. As the tubes have to be switched on only about one-tenth part of the time, they will last for ten times as many exposures, and the expense for new X-ray tubes will be reduced to one-tenth of the amount which has to be spent when these screens are not being used.

Moreover, it enables the owners of medium-sized coils to make successful exposures of even the most difficult parts of the body in such a short time that patients can keep their breath, and want of sharpness due to the movements during respiration is thus avoided.

The illustration shows the result obtained with our intensifying screens Nos. 2822–2826. That part of the plate which was covered by the screen

shows a normal picture; the original negative shows very fine details of the structure of the bones, which, however, will probably get lost in the reproduction and printing. That part of the plate which was not covered by the screen was so much under-exposed that no trace of the bones can be seen, only the outlines of the leg are visible.

The exposure was 10 M.A. seconds, with a tube which had a penetrating power of No. 7 on the Wehnelt scale, and the distance between anticathode and plate was 16 inches.

PRICES.

No. 2822.	$6\frac{1}{2} \times 8\frac{1}{2}$ in.	£1 8 0
No. 2823.	8 × 10 in.	2 2 0
No. 2824.	10 × 12 in.	2 10 0
No. 2825.	12 × 15 in.	3 10 0
No. 2826.	16 × 20 in.	5 10 0

It is important that the film side of the photo plate should be in **close contact** with the screen; the Cassettes No. 2855 of our list are convenient for this purpose. See also page 210.

[*Copy of an unsolicited testimonial.*]

SUNDERLAND, *Mar. 3rd*, 1911.

I am very pleased with the accelerating screen. It has solved the problem of Cranial Radiography for me. I can get a fully exposed negative of the orbit or accessory sinuses in 10 seconds. Faithfully yours,

A. C. NORMAN.

PLATES, CASSETTES, STEREOSCOPES, PROTECTING MASKS, AND PHOTOGRAPHIC UTENSILS.

PHOTOGRAPHIC PLATES FOR X RAYS.

The prices are per dozen. Plates of 8 in. × 10 in., or larger, can also be had in half-dozen boxes.

		Lumiere	W.A.H.	Wratten	Ilford
No. 2846.	$6\frac{1}{2}$ in. × $8\frac{1}{2}$ in.	**8/6**	**6/9**	**8/6**	**7/6**
No. 2847.	8 in. × 10 in.	**13/6**	**10/–**	**13/6**	**12/6**
No. 2848.	10 in. × 12 in.	**20/–**	**16/–**	**20/–**	**17/6**
No. 2849.	12 in. × 15 in.	**33/–**	**22/–**	**33/–**	**30/–**

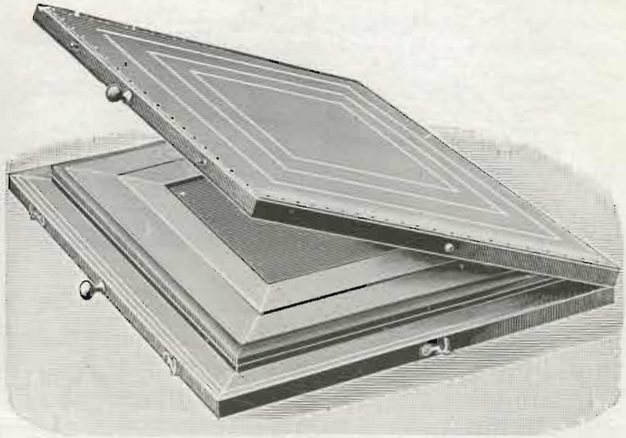
Plates can be supplied packed already in separate envelopes. This is to be recommended only if the plates are to be used within the next few days; they deteriorate if stored too long in envelopes.

No. 2851. **Plate Safe,** for storing unexposed plates in or near the X-ray room, 21 in. wide, 8 in. deep, 17 in. high.. **£1 15 0**

This is a box with lid, suitable for storing photographic plates of any size up to 16 × 20 in., and lined inside with thick sheet lead, to protect unexposed plates from the influence of X rays.

No. 2853. **Light-tight Yellow and Black Envelopes,** for protecting plates against daylight during exposure, $6\frac{1}{2} \times 8\frac{1}{2}$ in., **2/–**; 8 × 10 in., **3/6**; 10 × 12 in., **6/–**; 15 × 12 in., **10/–** per dozen.

No. 2853.



No. 2856.

No. 2855. **Light-tight Cassette,** for the reception of plates up to 10 × 12 in. £1 8 0

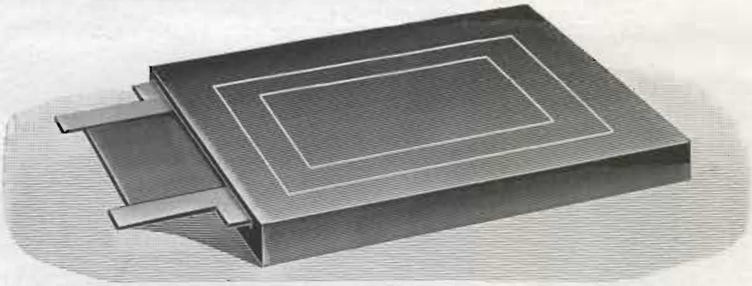
No. 2856. Similar **Cassette,** for plates up to 12 × 15 in., Fig. 2856 1 14 0

These cassettes are strong, light-tight, and the backs are lined with a sheet of lead to exclude secondary rays from below.

No. 2859.

No. 2859. **Film Holder,** for dental exposures, Fig. 2859 .. £0 12 0

No. 2860.



No. 2860

No. 2860. **Cassette,** for stereoscopic exposures, Fig. 2860, for plates up to 10 × 12 in. £1 7 0

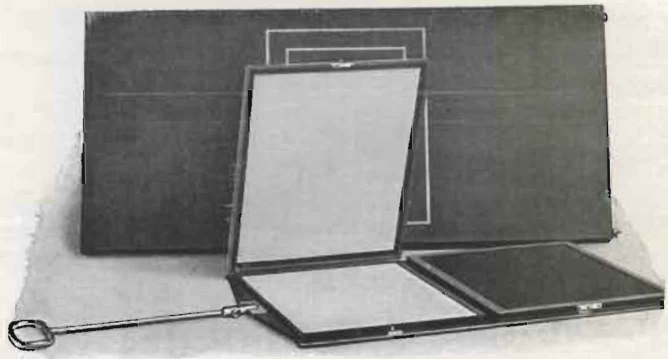
No. 2861. Similar **Cassette**, for plates up to 12 × 15 in. .. 1 16 0

These cassettes are lead lined, and so arranged that a plate can be exposed, withdrawn, and a new plate can be inserted instead *without disturbing the patient at all.* If the tube is shifted between the first and second exposure (see page 211) stereoscopic effects will be obtained if the plates are examined in the stereoscope described later on.

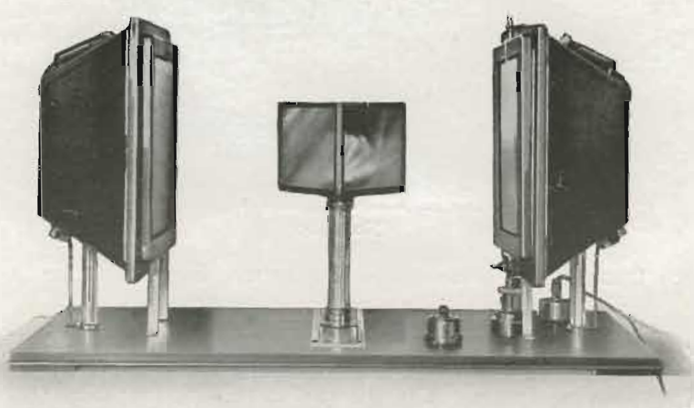
No. 2863.

No. 2863. **Sliding Cassette,** for stereoscopic exposures, for plates up to 16 × 20 in., Fig. 2863 .. .. £4 7 0

With this cassette two exposures are made on one plate. Two plates of metal cover either end of the cassette, the centre is made of transparent material. During one exposure, one-half of the plate is protected; the plate is then shifted, and during the second exposure, that half of the plate is protected which has been exposed already. On a plate measuring 16 × 20 in. two pictures 16 × 10 in. may thus be obtained.



No. 2865. **Tunnel Cassette,** for stereoscopic exposures, for plates up to 10 × 12 in. £9 12 0

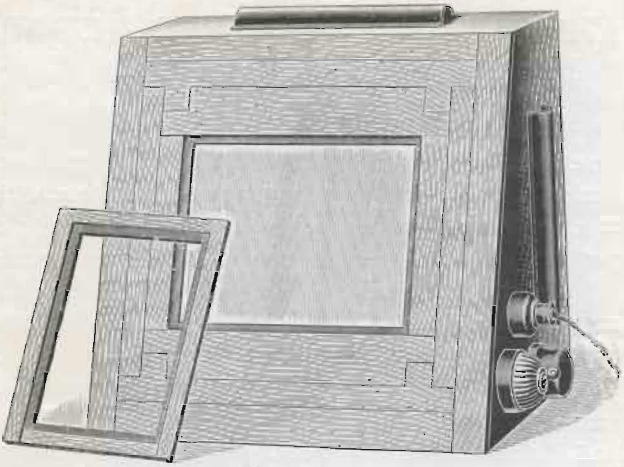


No. 2872.

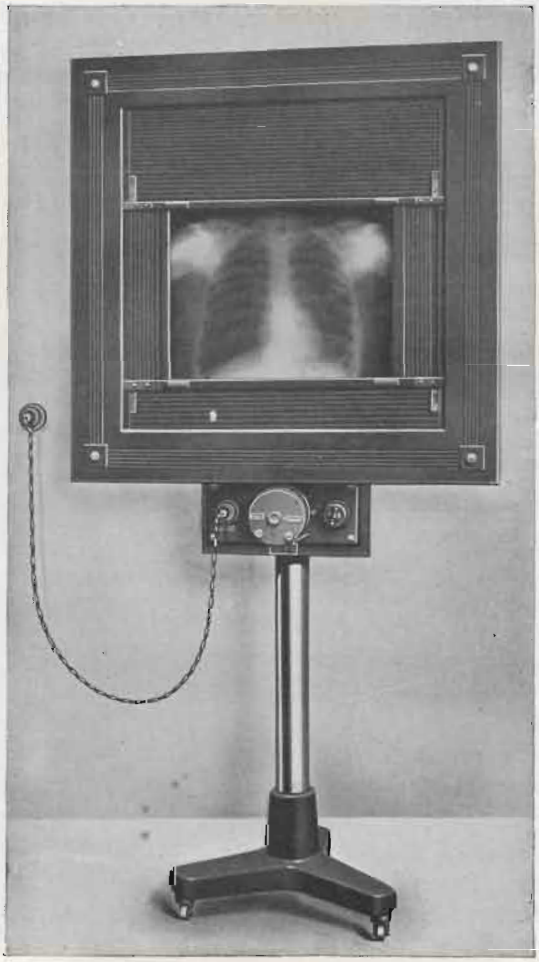
No. 2872. **Reflecting Stereoscope**, Fig. 2872, with carriers for plates up to 10 × 12 in. £9 0 0

No. 2887. Desk, with incandescent lamps and milk glass, to examine negatives measuring up to 14 × 14 in., and carriers for the smaller sizes of plates. Fig. 2887

£3 16 0



No. 2887.



No. 2889.

No. 2889. **Cabinet,** with milk glass to examine negatives. Roll shutters allow any size plate to be used, and any part of the negative to be screened, so that only the parts to be examined remain visible. The finest details can thus be discovered. Switch to turn on the incandescent lamps behind the milk glass, and rheostat to control the amount of light. Fig. 2889

£9 12 0

APPARATUS FOR MAKING PRINTS (OR DIAPOSITIVES) FROM X-RAY NEGATIVES ON A REDUCED SCALE.

With this apparatus prints can be finished within half an hour of the time the exposure was made, and before the negative has become dry or even washed. The prints can be exposed, developed, fixed, washed and dried much quicker than this can be done with X-ray plates, and surgeons need not be kept waiting for the result of an X-ray examination.

For large hospitals and for X-ray specialists it is a great saving in printing material, the bill for silver paper is reduced to less than one-fourth on account of the smaller size of the prints; no toning is required; and it is well known that with a little experience and skill, the quality of photographic pictures can be improved considerably by reduction. The pictures appear sharper, and if the illumination and exposure are chosen correctly, the contrasts can be made greater, so that faint shadows can be brought out better.

The apparatus required consists of:—

A *camera*, with bellows of suitable size and length, carrying at one end the negative to be reduced (or enlarged), at the other end a cassette, and half-way between these a rectilinear lens of suitable focus. The position of this lens can be altered to obtain reductions or enlargements on any desired scale.

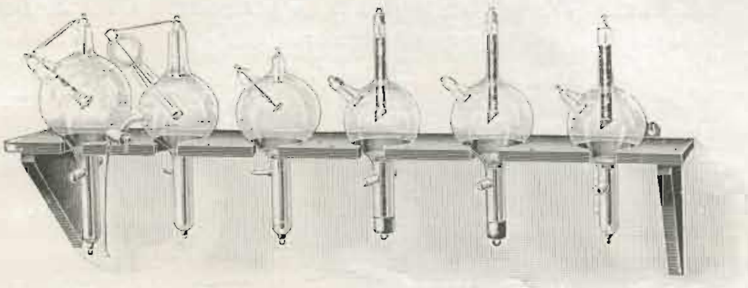
A *source of light to illuminate the negative evenly*. Daylight may be used, but varies very much in actinic power, and is not always available. Some 12 incandescent lamps may be placed behind a milk glass (see apparatus No. 2889), or else an arc lamp with a large condenser may be used. The incandescent lamps are cheaper, but give a diffused light, and exposures lasting 3 to 10 minutes may be necessary. The outlay for an arc lamp with condenser is more, but better results are obtained, because all the rays reaching the negative are *parallel*, giving a sharper, clearer picture, with more contrasts, than can be obtained with diffused light, and the exposure can be finished in 5 to 10 seconds.

Full details, illustrations and estimates of apparatus to suit special requirements will be sent on application.

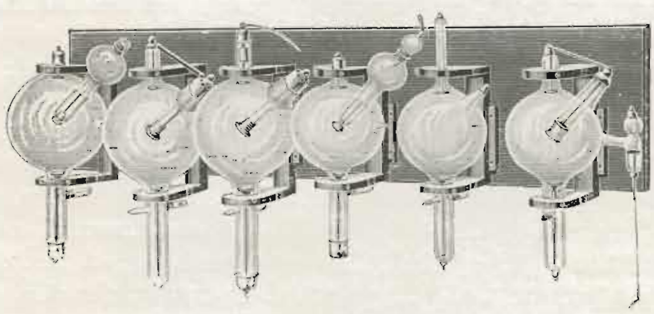
PROTECTIVE MATERIALS.

No. 2890.	**Gloves,** X-ray proof, per pair	£1	4	0
No. 2892.	**Spectacles** of X-ray proof glass	0	6	9
No. 2894.	**Head Mask** of X-ray proof rubber	1	15	6
No. 2896.	**Rubber Apron,** 24 in. wide, 38 in. long, best quality	3	0	0
	Ditto, cheaper quality	2	10	6
No. 2899.	**X-Ray Proof Rubber,** non-conducting, in sheets 24 in. wide, 40 in. long, best quality	2	1	0
	Ditto ditto second quality ..	1	12	0

WALL BRACKETS, to suspend 6 X-Ray Tubes.



No. 2920.



No. 2921.

No. 2920.	**Bracket,** to suspend 6 tubes, Fig. 2920 ..	£1 5 0
No. 2921.	,, ,, 6 tubes in self-centering holder, Fig. 2921	1 0 0
No. 2940.	**Cabinets for Storing Negatives,** for holding up to 1000 plates of various sizes in conveniently accessible drawers .. .. from **£6** to	10 0 0

Illustrations will be sent on application.

No. 2947.	**Set of Photographic Utensils** for plates up to 8 × 10 in., consisting of 1 xylonite and 2 porcelain dishes, 10 oz. graduated measure, ruby lamp, and 1 dozen light-tight envelopes..	1 5 0
No. 2947*a*.	Similar set, but for plates up to 12 × 15 in. .	1 15 0

ESTIMATES OF COMPLETE OUTFITS OF X-RAY APPARATUS.

In the following pages will be found description, illustrations and prices of some types of complete X-ray installations which we have found to be the most convenient, after having an experience with over five thousand similar installations.

As individual requirements vary a good deal, alterations or additions may become necessary, and in all such cases we shall be glad to prepare special estimates on application.*

The Outfits mentioned in the following pages can be seen working in our X-ray Laboratory at 71, New Cavendish Street, *where practical instruction in their use can be given to medical men.*

All our Outfits are now so arranged that coils, interrupters, etc., are fitted on cabinets or trolleys, so that the walls need not be disturbed by fixing coils, switchboards, etc., to them. This is a great convenience, especially in hospitals. The apparatus occupies little space, and either the switchboard or the whole apparatus can be moved easily, so that the operator has no occasion to turn round while handling the switches, rheostats, etc., but can give his attention to the tube. The operator is out of the way of the wires carrying high-tension currents, and the pegs on the rheostats, which are connected with 100 to 250 volt currents, are protected by glass covers, to prevent shocks through accidentally touching them.

The tubes are enclosed in X-ray proof boxes, so that patients, nurses and operator are thoroughly protected, and need not wear gloves, spectacles, aprons, etc.

The cost of a complete installation depends on the size of spark coil chosen, on the number of tubes, and accessories like tube stands, M.A. meters, etc. The larger coils, No. 2518 and No. 2521, have a material advantage for some of the more difficult *instantaneous* exposures; for instance, if negatives with sharp outlines of the stomach, the bowels, or very restless children have to be made, and are therefore to be recommended to X-ray specialists, and for the X-ray departments of large hospitals.

For the great majority of cases, and for all exposures for therapeutic purposes, Coil No. 2515 is amply powerful enough. Full details about the number of M.A. which can be reached with this coil, and the duration of exposure, will be found on page 230.

---

* Medical men and hospitals intending to fit up X-ray or other Electro-Medical Apparatus, will find it an advantage to apply to an expert before the definitive plan is settled. These apparatus have grown into a speciality of their own, in which improvements and new discoveries are frequently made. It is for this reason not likely that local electricians, instrument makers, or merchants can be so much up-to-date in these matters as experts who devote their whole time to them, and who have a long experience with installations of this kind.

No. 2951.

No. 2951. **Complete Outfit,** consisting of Spark Coil No. 2515 (see page 230), Mercury Interrupter No. 2524 or 2526, Switchboard on Trolley No. 2675, and with variable rheostats for coil and for motor of the interrupter, ampèremeter, switches, fuses, etc. Cabinet, 19 in. deep, 36 in. wide, and 69 in. high, as shown in illustration. The switchboard, while not in use, is placed in the lower part of the cabinet, the cable connecting it with the cabinet is 4½ yards long. Tube Stand No. 2612, with 3 flat diaphragms. Milliampèremeter No. 2721, with bracket to suspend it on tube stand, 2 Tubes No. 2542, 2 self-centering tube holders, cables and connections .. **£77 10 0**

If Coil No. 2518 is desired instead of No. 2515 (see page 231), the price will be **£95 0**s. **0**d.

No. 2953. **Complete Outfit,** as specified under No. 2951, but with the following instruments added: Cylinder Diaphragm No. 2613; Fluorescent Screen No. 2802, $9\frac{1}{2} \times 12$ in., with lead glass plate and protecting handles; Accelerating Screen No. 2825, 12×15 in.; Cassette No. 2856, 12×15 in.; Wehnelt Radiometer No. 2736; Slide Rule No. 2759, for calculating the duration of exposure; Spark Gap No. 2600, and Oscilloscope Tube No. 2609, to be fixed on the Tube Stand No. 2612; two additional Tubes No. 2542, and 2 self-centering tube holders; Bracket No. 2921, to suspend the tubes; and Couch No. 2650 .. .. **£105 0 0**

If the Apparatus Nos. 2951 and 2953 are required for an *alternating circuit*, the addition of Motor Transformer No. 2680 is recommended. This transformer converts the alternating into a continuous current of 110 volts and 10 ampères, which is ample if coil and interrupter are required for diagnostic purposes. If the coil is wanted for therapeutic purposes, Transformer No. 2682 should be used. The prices quoted for Nos. 2951 and 2953 will then be increased by **£40** and **£56** respectively.

The Apparatus Nos. 2535 *and* 2537 (described on page 241) *are also very convenient for alternating current supplies.*

If no current from the main is available, 12 to 15 accumulator cells of 50 ampère hours capacity, price **£12 18**s., or an engine with dynamo No. 2691, may be used.

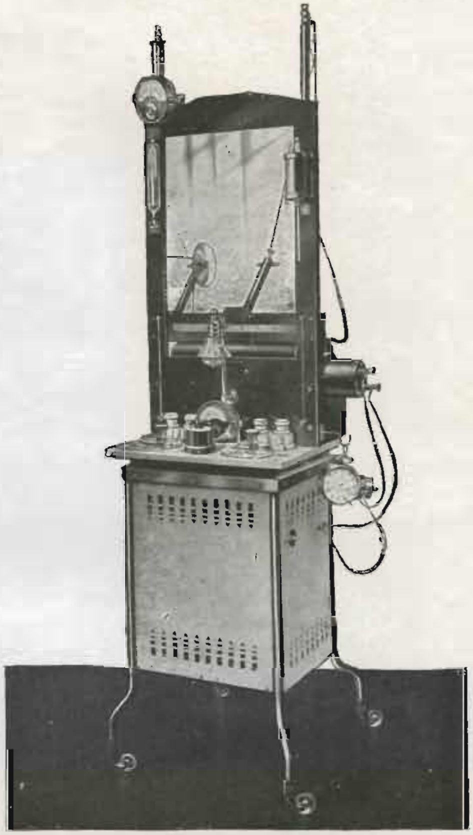
Our outfits Nos. 2951 to 2953 have been supplied amongst others to:—

County Hospital, Bedford; Essex County Hospital; Great Malvern Hospital; Grimsby and District Hospital; General Hospital, Ramsgate; King Edward Memorial Hospital, Lewisham; Kingston Victoria Hospital; Radium Institute, London; Royal United Infirmary, Bath; Royal Infirmary, Berwick; St. James's Infirmary, London; Victoria Central Hospital, Liscard; Tredegar Park Cottage Hospital; The Whangave's Hospital, New Zealand; British Hospital, Constantinople; Goculdas Tejpal Hospital, Bombay; Mildmay Mission Hospital; Newbury District Hospital; Victoria Central Hospital, Liscard; Wairarapa Hospital, Masterton, New Zealand.

Incorporated Orthopædic Hospital, Dublin.

Dr. Comrie, Edinburgh; Dr. J. C. Mackwood, Newick; Dr. F. W. Daniels, Newport; Dr. Patterson, Ascot; Dr. Fox, Warrington; Dr. G. Perry, Tiverton; Mr. R. Howard, Tunbridge Wells; Dr. T. A. Ross, Ventnor; Dr. J. B. McKay, Newport; Dr. E. B. Aubon, Auckland; Dr. Boxer, Hastings, N.Z.; Dr. J. F. Kidd, Ottawa; F. H. Westmacott, Manchester; L. H. Lewin, Oudtshoorn, South Africa.

No. 2955. **Spark Coil** No. 2515 (see page 230) on trolley of enamelled steel tubes, with marble plate, 22 in. wide and 20 in. deep, provided with Mercury Interrupter No. 2526, and switchboard with variable rheostats for spark coil and for motor of interrupter, ampèremeter, switches, fuses and signal lamp. A large lead glass screen separates all the parts carrying a high-tension current from the operator, and also affords protection from the X rays **£60 0 0**



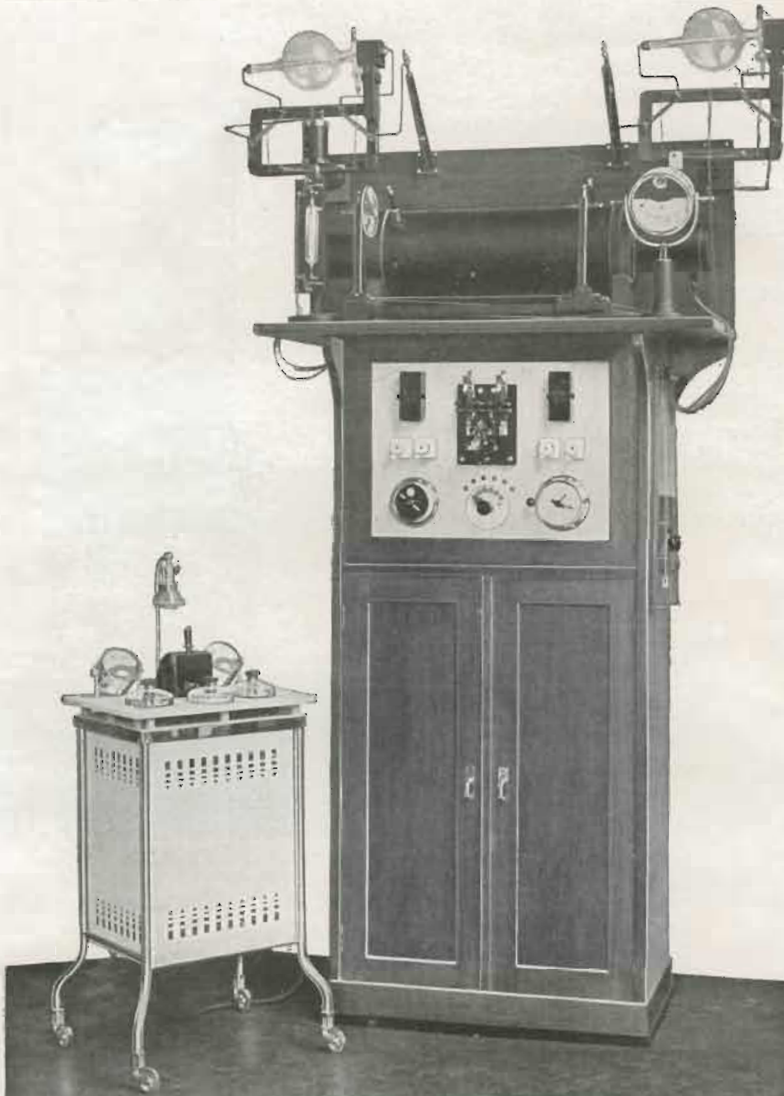
No. 2956.

No. 2956. The addition of a Milliampèremeter No. 2721, Oscilloscope Tube No. 2609, Spark Gap No. 2600 to suppress reverse current, adjustable parallel Spark Gap, and Clock No. 2762 to interrupt the primary current automatically after a previously set time, as shown in Fig. 2956, increases the cost of the Outfit No. 2955 to .. **£70 0 0**

This is a very convenient arrangement for consulting rooms, or for hospitals, for making negatives and for therapeutic exposures.

The addition of Tube Stand No. 2612 with 3 flat and 1 cylinder diaphragms, 3 Tubes No. 2542, 3 self-centering tube holders, 1 Fluorescent Screen No. 2802, $9\frac{1}{2} \times 12$ in., with lead glass plate and handles, Wehnelt Radiometer No. 2736, Slide rule No. 2759, and Bracket No. 2921 to suspend the tubes, will cost **£28 16**s. **0**d.

No. 2961. **Outfit, for X-ray Specialists, or large Hospitals.** Consisting of Coil No. 2518 (see page 231), with variable self induction and with condenser; Mercury Interrupter No. 2526; Multiple Electrolytic Interrupter No. 2533*c*; Switchboard, with the accessories mentioned under No. 2678, but arranged on a trolley; Cabinet, for the reception of the coil, the two interrupters, the switches for varying the self induction, inserting either mercury or electrolytic interrupter, and the switch and clockwork for instantaneous exposure and automatic time release; three X-ray Tubes No. 2544, 2 Valve Tubes No. 2607, and 2 Valve Tube Holders No. 2608, with high-tension change-over switch; 6 self-centering Tube Holders, Milliampèremeter No. 2726, large size, suspended on porcelain column; Wehnelt Radiometer No. 2736; Slide Rule No. 2759; Fluorescent Screen No. 2802, $9\frac{1}{2} \times 12$ in., with lead glass plate and protecting



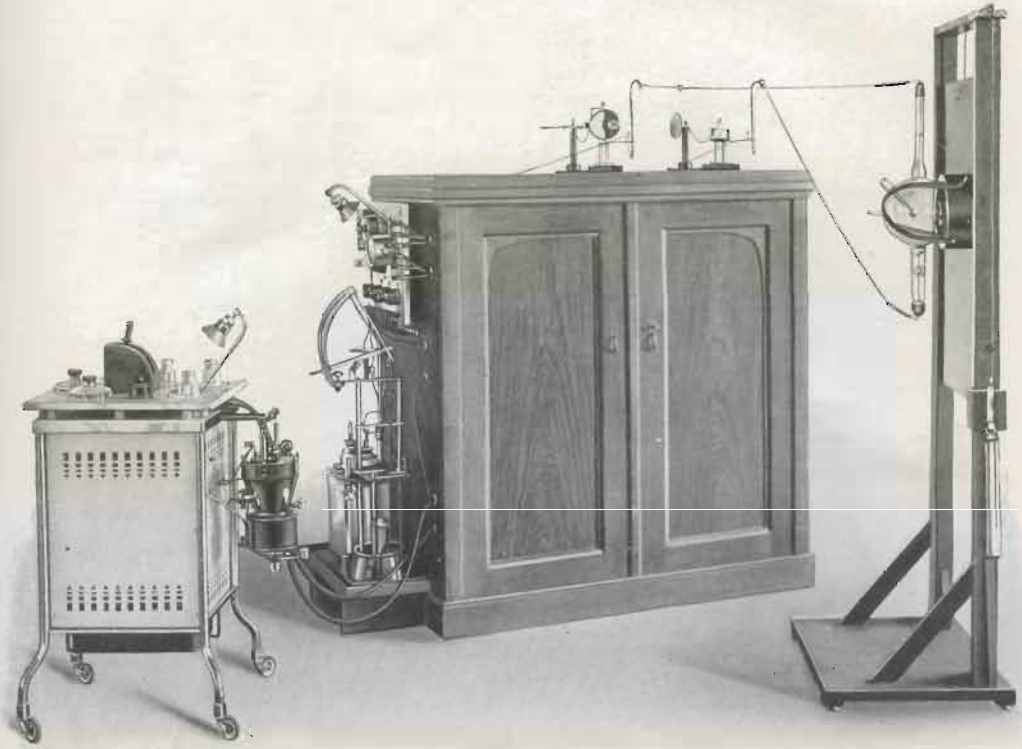
No. 2961.

handles; Accelerating Screen No. 2825, 12 × 15 in.; Cassette No. 2856; Bracket No. 2921, to suspend the tubes; Cables; connecting Wires .. **£150 0 0**

One of the Tube Stands Nos. 2612, or 2616, or 2617, and a Couch, or else the Orthoscope No. 2620, have to be added to make this outfit complete.

We have supplied such outfits amongst others to:—

Dr. Ironside Bruce; Sir David Salomons; Lieut.-Col. Drake Brookman; Mr. Coldwell; R. H. Dix, Sunderland; Dr. Harris, Sydney; Dr. Marchesini, Auckland; General Infirmary, Chichester; Infirmary, Warrington; South Shields Union; Royal Prince Alfred Hospital, Sydney; St. Margaret's Hospital, Launceston; Civil Dispensary, Kasur; The Hospital, Dunedin; Royal Alexandra Hospital for Children, Sydney; General Hospital, Mysore, India; H. D. O'Sullivan, Burton-on-Trent.



No. 2964.

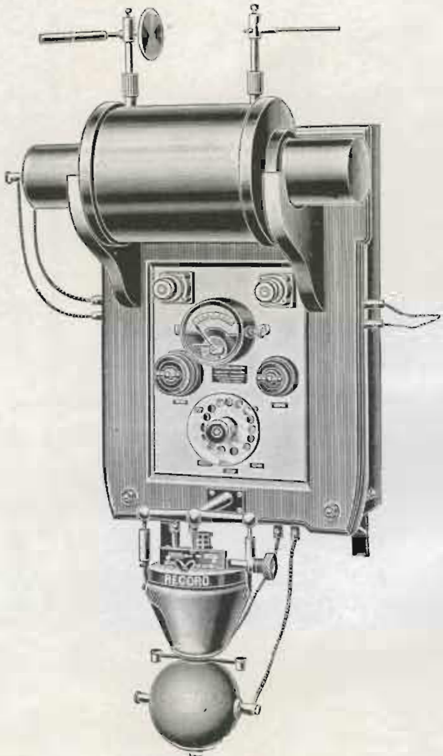
No. 2964. **Spark Coil** No. 2521, for instantaneous exposures with one single flash (see page 231); in cabinet, with special mercury interrupter for single flash exposures and with Mercury Interrupter No. 2526 for time exposures, examination on the screen, and for exposures for therapeutic purposes; large Switchboard on trolley, Ampèremeter, Milliampèremeter No. 2726, on bracket, and tube stand with protecting screen, for single-flash exposures, as shown in illustration **£185 0 0**

(As supplied to Westminster Hospital and to Dr. Worrall.)

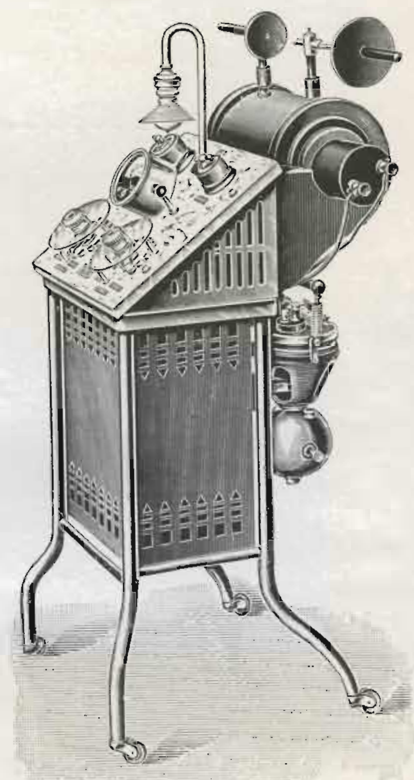
With this apparatus good negatives of any part of the body, with the exception of the lumbar region and the pelvis, can be obtained with one single flash, i.e., in about the $\frac{1}{200}$th part of a second. Good negatives of the pelvis or kidney of an adult can be obtained with time exposures in 12 seconds *without* an accelerating screen, or in about 0·2 seconds with an accelerating screen.

The apparatus can be used equally well for examinations on fluorescent screens, and for all therapeutic purposes.

It is the most powerful apparatus existing, and a universal apparatus for X-ray Specialists and large Hospitals.



No. 2967.



No. 2968.

X-Ray Apparatus for Dental Purposes, or for treating **Ringworm,** etc.; consisting of Spark Coil No. 2512, with Mercury Interrupter No. 2526, switchboard with variable resistances for coil and for motor of interrupter, ampèremeter, switches, fuses.

No. 2967.	Apparatus on wall bracket, as shown in Fig. 2967 ..	**£38 0 0**
No. 2968.	Similar Outfit, but coil, etc., mounted on trolley, as shown in Fig. 2968	**46 0 0**

The following accessories will also be required for making negatives of teeth :—

Tube Stand No. 2612, with diaphragm No. 2614*r* for centering tube, so that the central ray can be directed perpendicularly to the tooth or part of the jaw to be taken; 2 X-ray Tubes No. 2541; Milliampèremeter No. 2721; Fluorescent Screens No. 2800, 5 × 7 in., and No. 2820, and Film Holder No. 2859; cables and cords **£23 5 0**

As supplied to G. S. Morris, Upper Brook Street, London; J. H. Gibbs, Edinburgh; V. Cotterell, Grosvenor Street; Dr. Achner, 47b, Welbeck Street, etc.

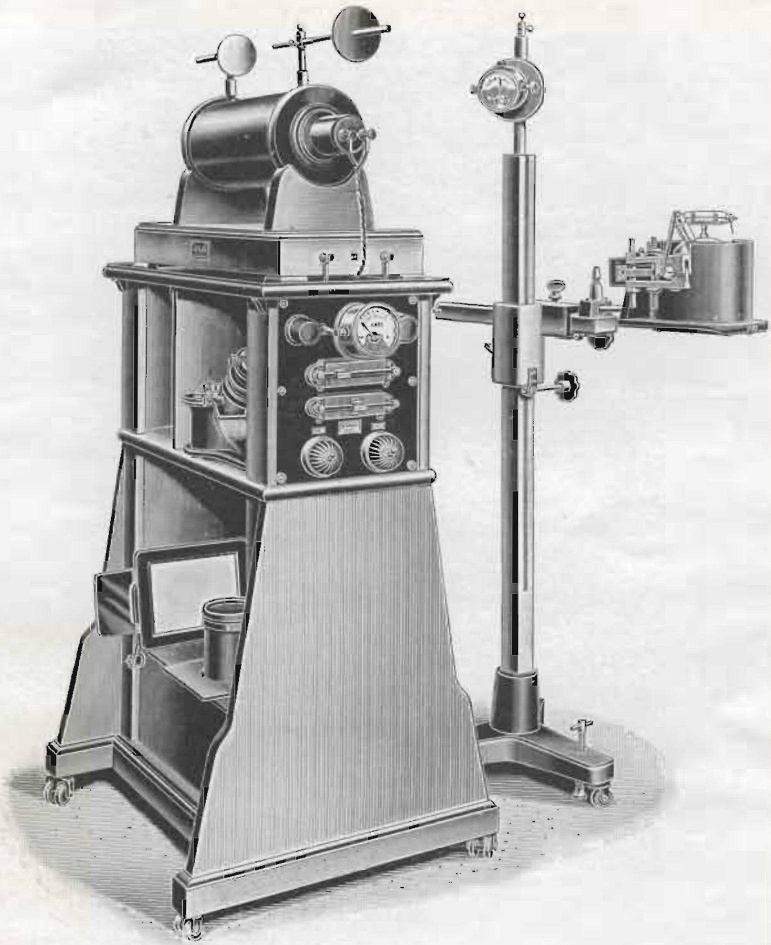
No. 2972.

No. 2972. **Complete Outfit** for treating **Women's Diseases** with X rays; consisting of: Spark Coil No. 2515; Interrupter No. 2524; Rhythmic Interrupter No. 2528, and change-over switch for it; Switchboard on trolley No. 2675*a*; Cabinet as shown in illustration (or large trolley similar to Fig. 2956); Tube Stand No. 2612, with cylinder diaphragm and 3 aluminium filters; Milliampèremeter No. 2721, with bracket, to suspend it on tube stand; Oscilloscope Tube No. 2609, and Spark Gap No. 2600; Wehnelt Radiometer No. 2736, and 3 Tubes, No. 2570 or No. 2577; cables and connecting wires **£104 0 0**

No. 2975. **Complete Outfit** for treating **Ringworm** and other diseases of the skin; consisting of: Spark Coil No. 2512; Interrupter No. 2524; Switch Board No. 2675, and trolley or cabinet to hold coil, interrupter and switchboard; Tube Stand No. 2612, with Diaphragm No. 2614 for exposing Sabouraud pastilles, and 2614*e* (or 4 lead glass Tubes No. 2614*a*); 1 Booklet with Sabouraud Pastilles; Milliampèremeter No. 2721, Spark Gap No. 2600, and Oscilloscope Tube No. 2609 suspended on the tube stand; Radiometer No. 2735; 2 Tubes No. 2542; cables and connections **£67 0 0**

No. 2981. **Complete Outfit for Hospitals,** arranged on a strong trolley of oak, with large casters with rubber tyres, so that it can be wheeled into the wards (Fig. 2982); and consisting of: Spark Coil No. 2515 (see page 230); Mercury Interrupter No. 2524; Switchboard with variable rheostats for the spark coil and for the motor of the interrupter, ampèremeter, switches and fuses; 2 Tubes No. 2542; 2 Self-centering Tube Holders; Tube Stand No. 2612 with 3 flat diaphragms and with cylinder diaphragm; Milliampèremeter No. 2721, and bracket to suspend it on tube stand; Fluorescent Screen No. 2801, 7 × 9½ in., with lead glass and protecting handles; Accelerating Screen No. 2824, 10 × 12 in.; Cassette No. 2855; Wehnelt Radiometer No. 2735; Slide Rule No. 2759; cables and connections .. **£80 0 0**

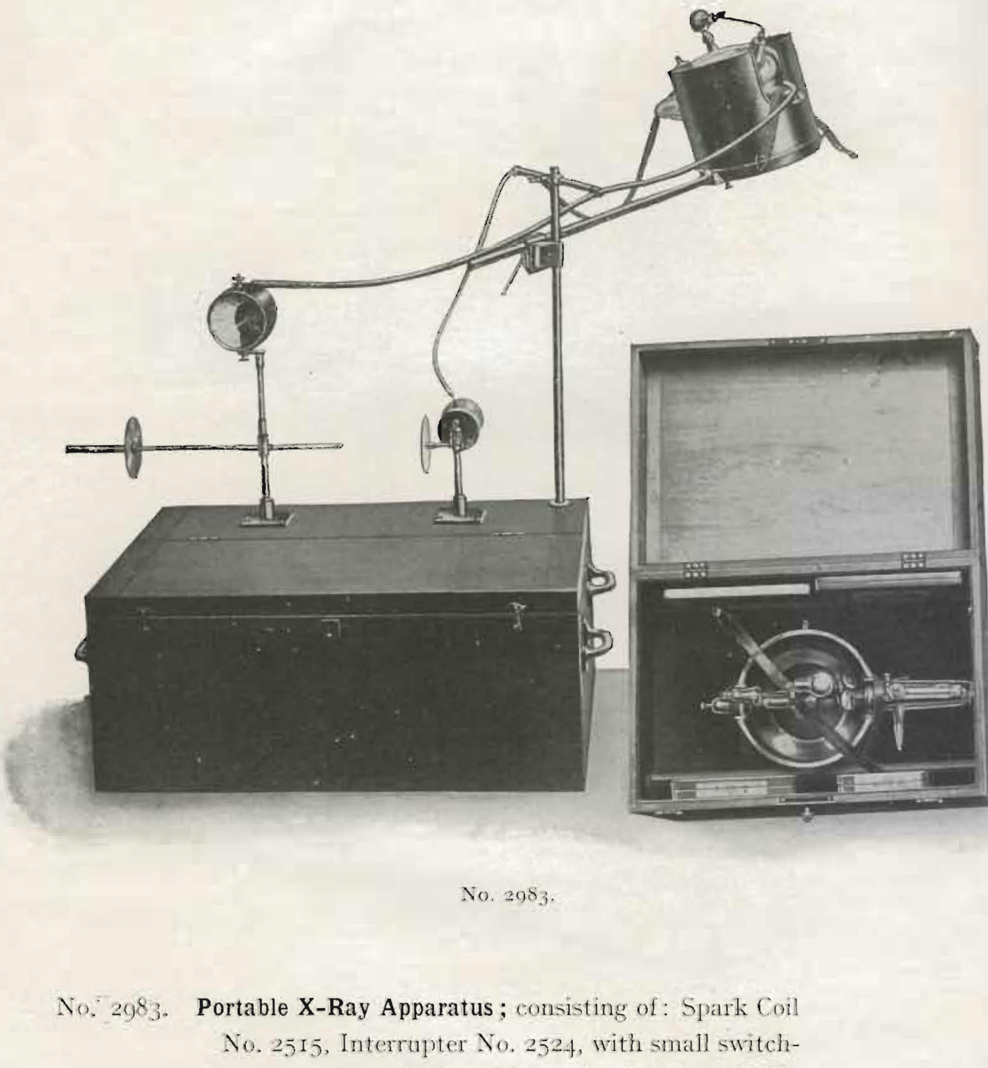
If desired, the rheostat can be so arranged that the primary current cannot exceed 5 amps. while using the apparatus from ordinary wall plugs in the wards. By turning a switch, currents up to 15 amps. may be used for rapid exposures when the apparatus is in an operating theatre or an X-ray room, where the cables and fuses allow 15 amps. to be used.



No. 2982.

No. 2982 **Similar Apparatus,** but provided with twelve accumulator cells of 50 ampère hour capacity, for hospitals where no continuous current from the main is available **£86 0 0**

The illustration shows the apparatus with the accumulators on the base of the trolley.

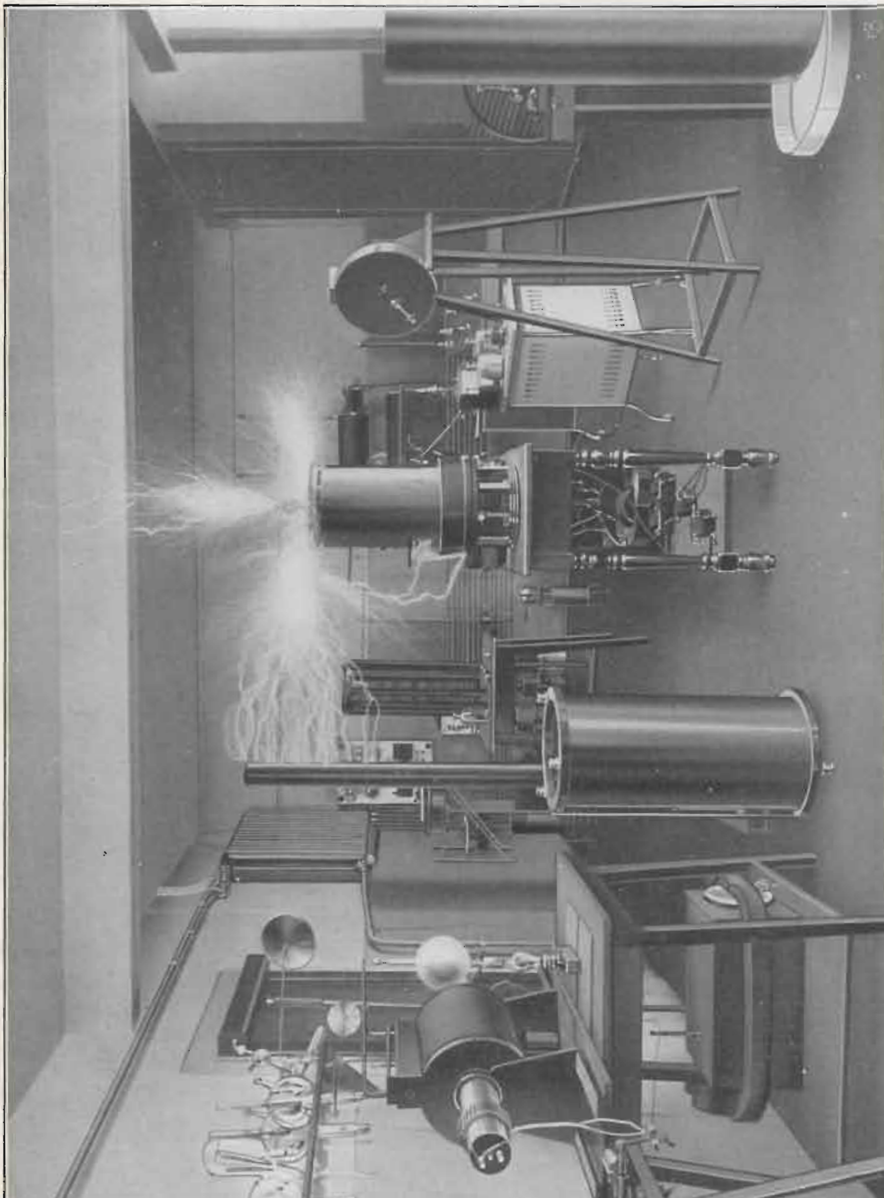


No. 2983.

No. 2983. **Portable X-Ray Apparatus;** consisting of: Spark Coil No. 2515, Interrupter No. 2524, with small switchboard; Tube Stand with protecting box, Milliampèremeter No. 2721; Tube No. 2542; Fluorescent Screen No. 2801; Cassette No. 2855; and Accelerating Screen No. 2824; cables, connecting wires and 1 dozen Plates; arranged in 3 portable cases of oak **£60 0 0**

There are no projecting terminals, the connections are made with plug contacts sunk into the cases. To work the apparatus, two 12-volt 30 ampère hour accumulators are required, price **£10.**

APPARATUS FOR HIGH-FREQUENCY CURRENTS.



No. 3014.

No. 3014. **New Portable High-frequency Apparatus,** Fig. 3014 **£14 0 0**

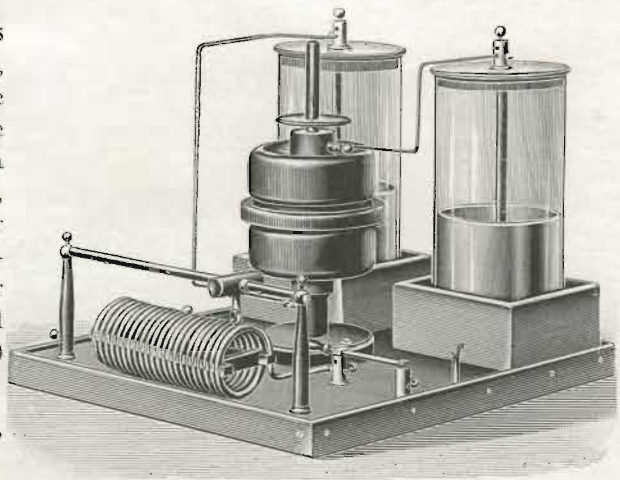
In spite of the small size, high-frequency currents up to 250 M.A. can be reached with this new apparatus. It can be connected with a continuous or an alternating current supply, is simple to manage, and no spark coil is required. The effluve is steady, gives no pain, and has an excellent sedative effect. The electrodes shown on page 308 can be used with this apparatus.

If provided with an additional transformer, the same apparatus may be used for the production of X rays. They are of course not as intense as those obtained with a large spark coil, but are sufficient for making negatives of teeth, hands, arms, etc.

No. 3016. **New Portable High-frequency Apparatus,** similar to No. 3014, but with an additional transformer, so that it can be used for the production of X rays as well **£20 0 0**

No. 3030. **D'Arsonval's Transformer,** Fig. 3030, consisting of two large Leyden jars, adjustable spark-gap enclosed in a case with glass windows, solenoid of stout copper wire with sliding contact to insert more or less turns, switch and terminals .. **£6 0 0**

Size of the Leyden jars:
Diameter $6\frac{1}{2}$ ins., height 14 ins.



No. 3030.

No. 3032. **Apparatus**, consisting of d'Arsonval transformer, No. 3030, with large Leyden jars, spark-gap, and resonator, arranged on a table of polished mahogany, as shown in Fig. 3032 .. .. **£16 10 0**

Size of the apparatus: 21 in. by 21 in., total height 62 in.

If a separate small tuning spiral is added, the price of the apparatus will be **£17.**

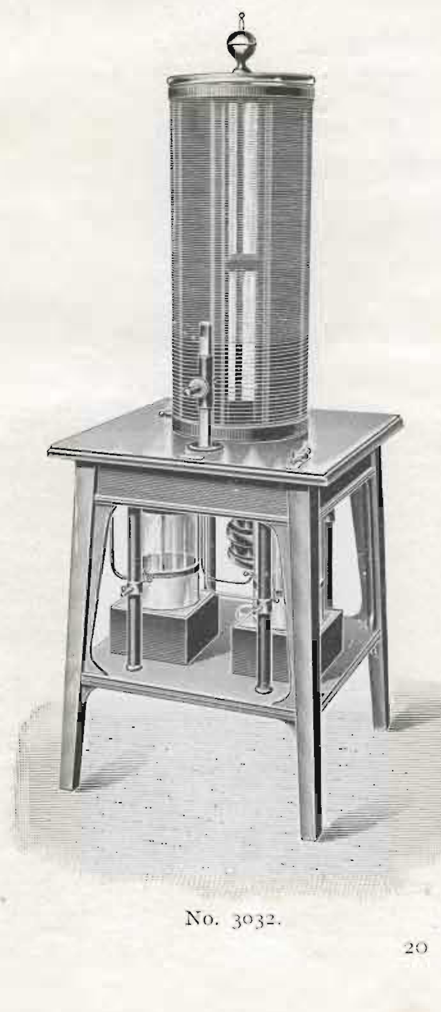
(As supplied to H. Lewis Jones, M.D., E. R. Morton, M.D., W. Tyrrell, W. M. A. Anderson, F. Little, F. W. Morison; Royal Infirmary, Edinburgh; London Hospital; St. George's Hospital, Royal Victoria Hospital, Belfast; Westminster Hospital; Civil Dispensary, Rasur, India; Dr. Rawson, New Zealand; Dr. Moll, Johannesburg; Dr. Box, Stratford-on-Avon; Dr. Durk, Swansea; India Office, etc., etc.

[*Copy of unsolicited Testimonial.*]

SUNDERLAND,
Sept. 27th, 1910

I bought a High-Frequency Installation which you supplied to the late Dr. Daglish, of this town. Allow me to congratulate you on the workmanship.

JAMES B. WATERS, M.A.,
(*In charge of the Electrical Department*).



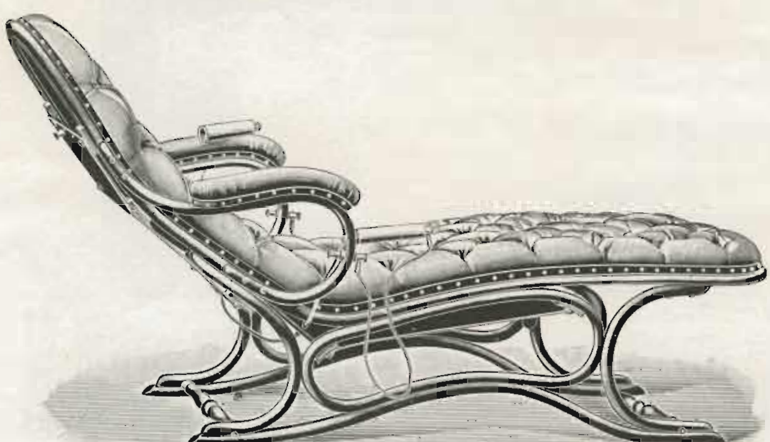
No. 3032.

GALVANOMETERS, COUCHES, AND ELECTRODES FOR HIGH-FREQUENCY CURRENTS.

No. 3041.

No. 3041. **Milliamperemeter,** Fig. 3041, registering up to 500 milliampères **£4 4 0**

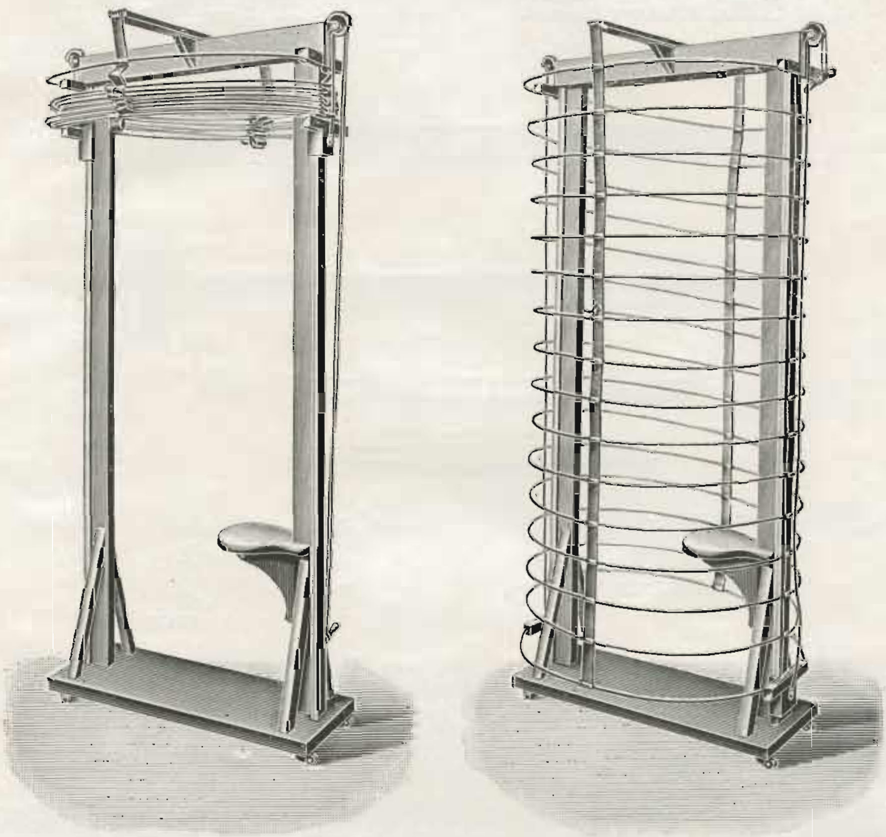
Galvanometers registering up to 1,000 milliampères can be made to order.



No. 3051.

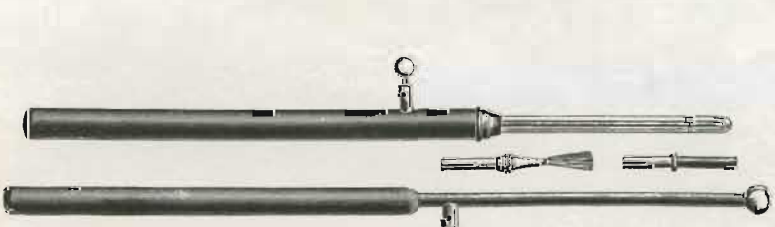
No. 3051. **Condensating Couch,** of Austrian bentwood, thick horsehair mattress covered with dark leather, insulated zinc sheet, and two large electrodes, Fig. 3051 .. .. **£9 0 0**

If covered with cloth only, the couch will be **30**/- cheaper.



No. 3055

No. 3055. **Solenoid,** Fig. 3055, to enclose the patient. It can be raised or lowered like a Venetian blind .. £12 6 0

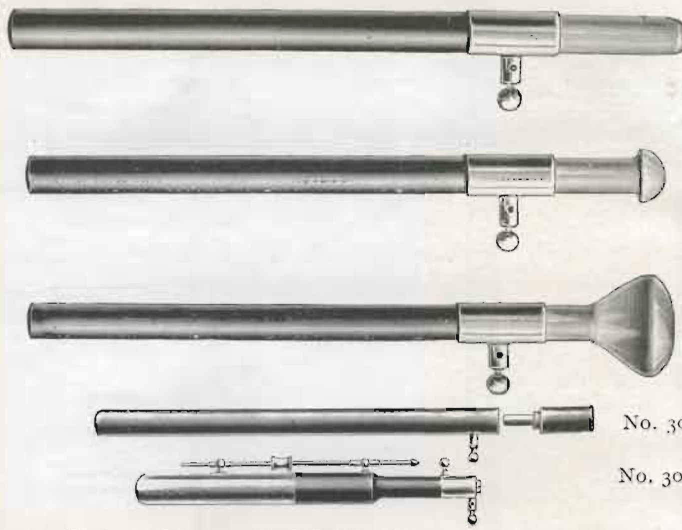


No. 3070.

No. 3072.

No. 3070. **Oudin's Condensator Electrode,** Fig. 3070 .. £0 15 0

No. 3072. **Ebonite Handle,** Fig. 3072, for the reception of brush, point, ball, or vacuum, etc., electrodes, 12-in. long 0 12 0

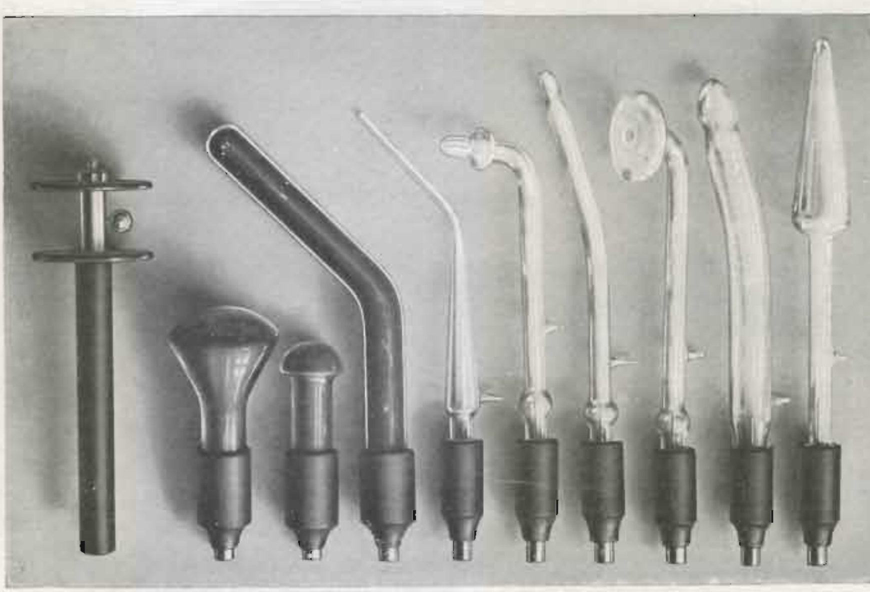


No. 3074.

No. 3076.

No. 3076. **Handle,** 12 inches long, Fig. 3076, with adjustable spark-gap, for the reception of different electrodes — **£1 1 0**

No 3080. **Metal Points, Brushes, Balls,** etc., for handle No. 3072, each — **0 2 6**



3084.

No. 3084. **Dr. Macintyre's Vacuum Electrodes** of glass, for application to the skin, ear, rectum, uterus, etc. (see illustrations, Fig. 3084) .. .. each — **£0 7 6**

No. 3085. **Complete Set of Six Vacuum Electrodes,** including handle No. 3072 .. .. — **2 12 0**

No. 3090.	**Conical Electrode** of thin hollow metal, nickel-plated, for treating hæmorrhoids	£0 12 6
No. 3092.	**Multiple Point Electrode,** with twenty-five points in ebonite cup, diameter $2\frac{1}{2}$ inches (the electrode fits handles Nos. 3072—3076)	0 18 0
No. 3140.	**Heavily Insulated Conducting Cords,** 5 feet long, for high-frequency currents .. per pair	0 14 0

Estimates for complete Installations, including spark coil, interrupters, and switchboards, and references to literature about this subject, will be sent on application.

For a *complete* installation of High-Frequency Apparatus, a Spark Coil and Interrupter are necessary in addition to a Solenoid like No. 3032. The spark coils used for X rays will do well. If a coil is not available, Coil No. 2512 is quite sufficient for the production of powerful high-frequency currents.

No. 3190.	**A Complete Installation,** consisting of: Coil No. 2512, Interrupter No. 2524, Switchboard No. 2672, High-frequency Apparatus No. 3032, Couch No. 3051, and a set of highly insulated cables, a long ebonite handle, and a set of 5 Electrodes	£60 0 0

THERMO PENETRATION, OR DIATHERMY.

A new method has been found for raising the temperature of the body.

Heat has been used as a therapeutic agent for ages, partly because pain can be relieved by it, and partly because nature herself teaches us that to get rid of some diseases, the temperature of the body must be increased to fever heat. Some infectious micro-organisms are killed, and some crystalline deposits of urates, etc., become soluble if the temperature is raised a few degrees above the normal.

The old-fashioned hot-water bottle, and the newer Turkish, electric light, and hot-air baths do, however, not affect the *internal* temperature. They make the skin hyperæmic, produce perspiration, and are for this reason very useful in many cases; but the perspiration acts as a wet blanket and protects the internal organs against an increase of the temperature, which can easily be proved with a thermometer.

Electric currents have the peculiarity of heating the conductors through which they pass; if the latter are thin in proportion to the strength of current used, they become even incandescent, like the filaments of incandescent lamps or platinum burners, etc. It was, however, impossible for a long time to send through the human body currents strong enough to affect the temperature on account of the physiological and chemical effects produced by the movement of ions. If a continuous current be used, even weak currents become painful in consequence of the chemical effects, and alternating or faradic currents of the usual low frequency cause painful contractions, long before any thermal

effects can be noticed. Some fifteen years ago, Tesla showed that by using the rapid oscillations set up by the discharge of Leyden jars as an interrupter to reverse the direction of currents about 100,000 times per second, currents of a strength which would be fatal with a low frequency can be passed through the human body without causing any harm. A current of even half an ampère, sufficient to light an incandescent lamp, can be sent through the body. The explanation is that on account of a certain amount of inertia, the ions are not set in motion if the direction of the current changes so frequently. Currents of this kind are being used for therapeutic purposes, as the d'Arsonval

No. 3200.

high-frequency currents. The strength employed varies usually between 0·1 and 0·3 amps., in some cases even 0·6 or 0·8 amps. were reached, and a sensation of warmth is produced with strong currents of this kind, but they become rather unpleasant, and partly for this reason, and partly on account of the construction of the apparatus, stronger currents cannot be employed with the d'Arsonval high-frequency apparatus.

For wireless telegraphy, interrupters were invented to send out a much larger number of waves of even strength. This has been achieved by keeping

the electrodes between which the discharge takes place as cool as possible. They are made therefore of large, heavy copper blocks, provided with ribs to radiate the heat. As hydrogen conducts heat much better than air, alcohol vapours are used in addition to the rib cooling in one type of interrupter, to surround the spark with an atmosphere of hydrogen to carry off the heat. With interrupters of this type frequencies as high as 3,000,000 per second can be reached, and the waves are of such a regularity that currents of any strength can be applied without causing the usual physiological or chemical effects of electric currents. **The only sensation produced is heat,** but if a certain strength is exceeded, blisters will appear, and the albumen in the blood may coagulate. Currents of ½ to 1½ amps. can be borne easily, and as much as 3 amps. have been applied; but with currents of this strength the sensation of heat becomes intense, not only at the spot where the electrodes are applied, but in any part between the electrodes. The temperature rises, and fever can be produced artificially, but it can be localized, and its duration and intensity is under control. The curative agent used with this method is **heat**, not electricity; the latter serves only to generate the heat. It is impossible for the patient to obtain a shock from the electric current, because it has been transformed by induction. Even if the primary current should stop, or become short-circuited, the only result will be a cessation of the heat, without causing any shock. Any large flexible electrodes making a uniform good contact can be used; special electrodes filled with moss and soaked in a 2–4 per cent solution of salt are very good for the purpose, and the four-cell bath may also be used.

Excellent results have been already reported by treating with this method colds, rheumatic or gouty affections, sciatica, diseases of the respiratory organs, neuralgia, sleeplessness, nephritis, etc., and in relieving pain.

A list of the literature on the subject will be sent on application.

The same currents can also be used very well for **surgical purposes.** If the current is concentrated on a small area by applying it with small metal plates or needles, the density can be increased so far that tumours can be destroyed by coagulation, so that an abscess is formed afterwards. If a needle electrode connected with the apparatus is passed over the skin, small sparks discharge, burning the flesh, and deep incisions can thus be made **without hæmorrhage.** This is of advantage in some gynæcological operations, and in operating on infectious cases, malignant growths, tuberculous diseases, etc., where it is of importance that the blood should not carry infectious material to healthy parts. By adjusting the strength of the current, the spark can be made to cut only, without causing necrosis of tissues in the neighbourhood; or it can be increased so that the adjoining tissues become charred to a depth of $\frac{1}{10}$th or $\frac{2}{10}$th of a mm., and fulguration can be applied with it after an operation with a knife.

No 3200. **Universal Apparatus** for diathermy, cold cautery, etc., Fig. 3200 .. .. **£46 0 0**

The apparatus is mounted on a trolley of enamelled steel tubes, with a marble top. It is provided with two spark gaps with perfect cooling arrange-

ment (including alcohol vapours), which may be used separately or combined ; a variable rheostat, and a variable transformer, to control the strength of the secondary current gradually, in the widest limits. A hot wire ampèremeter, indicating up to 3, or, if desired, up to 5 ampères.

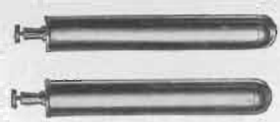
The apparatus has to be connected with an **alternating** current. Where the **continuous** current is laid on it is necessary to use a motor transformer, to convert it into an alternating current. Price of this transformer, including necessary rheostat .. **£27 0 0**

The apparatus No. 3200 can also be used for a Condensating Couch No. 3051, or for auto-conduction with Solenoid No. 3055.

To a limited extent the apparatus can also be used for the production of X rays. A special small solenoid has to be connected with the apparatus for this purpose, and the cathode only of an X-ray tube is to be connected with the end of this solenoid. The light obtained is absolutely steady, with a sharp division between luminous and dark part of the tube, and the tubes last a long time. The X rays obtained cannot be as intense as those reached with large spark coils, but are sufficient in some cases where *short* exposures are not important.

No. 3202.	Similar apparatus for cold cautery only, for **alternating** supply	£28 0 0
	Motor Transformer, to use apparatus No. 3202 on a **continuous** current supply	18 0 0

ELECTRODES FOR DIATHERMY AND COLD CAUTERY.



No. 3210.

No. 3230.

No. 3210.	**1 Pair Large Metal Handles** with terminals ..	£0 7 0
No. 3212.	**1 Pair of Cords,** 4½ feet long, with thick rubber insulation	0 7 6
No. 3214.	**1 Pair of Flexible Electrodes,** 4 by 4 inches, including a pair of cords	0 12 9
No. 3216.	**Similar Electrodes,** 4 by 6 inches, with cords ..	0 15 0
No. 3220.	**Electrodes for Coagulation,** including two ebonite handles	1 14 0
No. 3230.	**Set of 4 Platinum Iridium Needles** with ebonite handles, for cold cautery Fig. 3230	2 15 0

VARIOUS INSTRUMENTS.

UNIVERSAL APPARATUS

FOR RECORDING THE PULSE,

THE MOVEMENTS AND SOUNDS OF THE HEART,

AND

THE ELECTRO-CARDIOGRAM

(BOCK-THOMA ELECTRO CARDIOGRAPH.)

As supplied to: Prof. Waller, University, South Kensington; The Heart Hospital; Royal Infirmary, Edinburgh, etc., etc.

WITH this apparatus four tracings can be obtained synchronously on the same strip of sensitive paper of :—

1. The Electro-Cardiogram;
2. The mechanical movements of the Heart Pulse (radialis carotis); and
3. The Sounds of the Heart.

The mechanical and acoustic impulses are converted into electrical impulses by means of microphones, and therefore processes taking place at the same time are also recorded synchronously, so that their relation to one another can be studied.

The Apparatus consists of a powerful electro-magnet. Four small mirror galvanometers are fixed between the poles of this magnet so that ·001 volt or less produce currents sufficient to deflect the mirrors. The light of an arc lamp is reflected by them and projected on to a camera, in which a strip of sensitive bromide of silver paper is drawn across a slot. Every tenth of a second a mark is made on the paper, so that the time elapsing between the various processes is also recorded.

The **Electro-cardiogram** records the variations in the electric currents generated by the action of the heart. The electrodes may be applied to the arms or feet, or one arm and one foot, etc. As three curves can be taken

Fig. I.

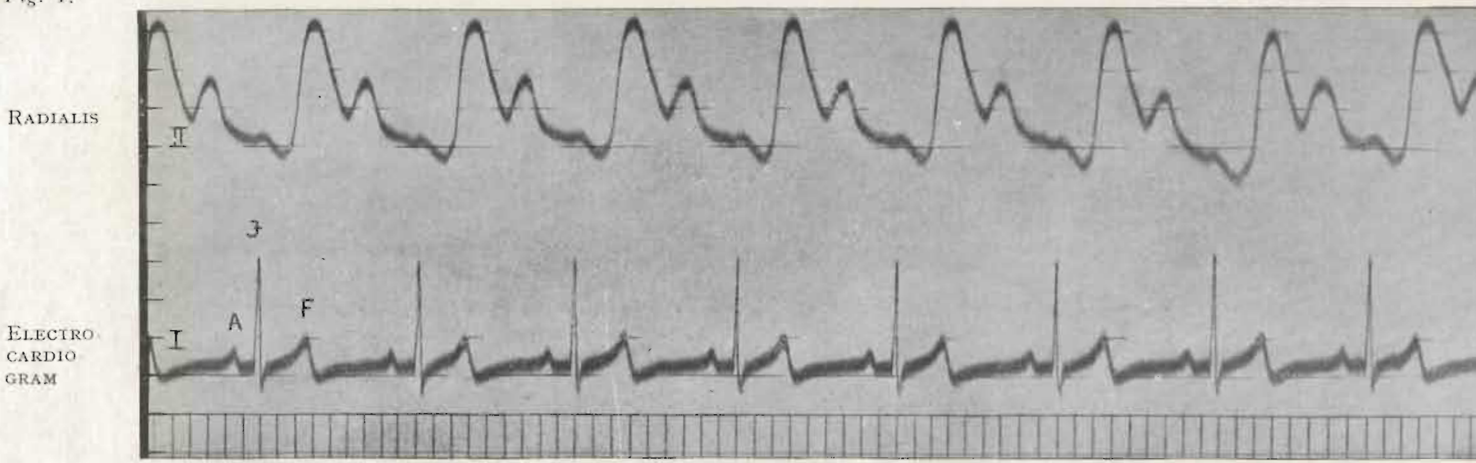

RADIALIS
ELECTRO
CARDIO
GRAM
II
I
A
3
F

Fig. II.


HEART
SOUNDS
RADIALIS
ELECTRO-
CARDIO-
GRAM
III
II
I
3
A
F

Fig. III.

Heart Sounds

Radialis

Electro-cardio-gram Hand and Foot

Ditto Both Hands

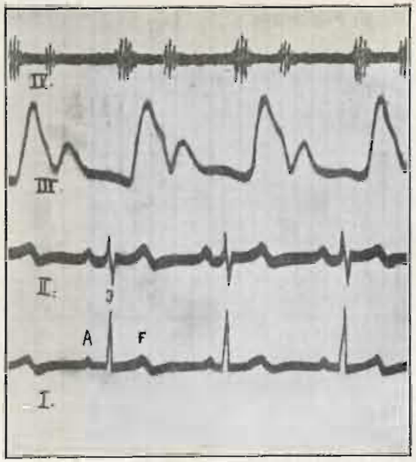


Fig. IV.

Radialis

Electro-cardio-gram

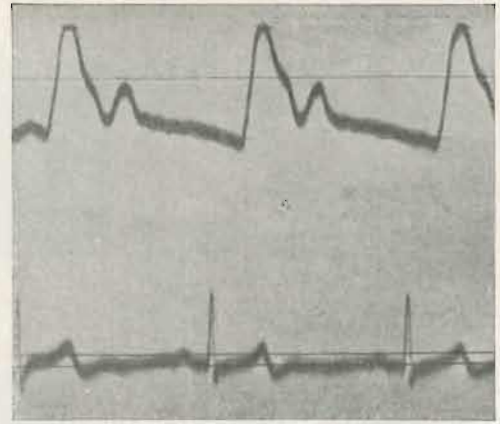
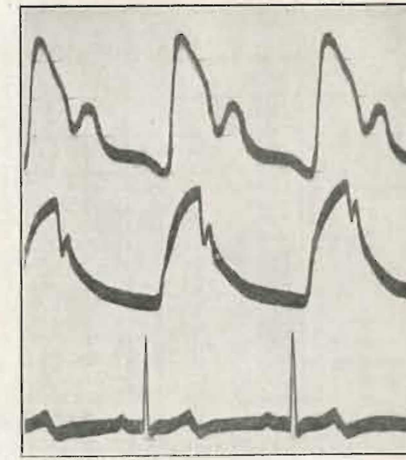


Fig. V.

Radialis

Carotis

Electro-cardio-gram



THE SIX PAIR OF EXTREMITIES. Electro-Cardiograms on two slips.

Fig. VI.

I. Right Arm Left Arm

II. Right Arm Left Foot

III. Left Arm Left Foot

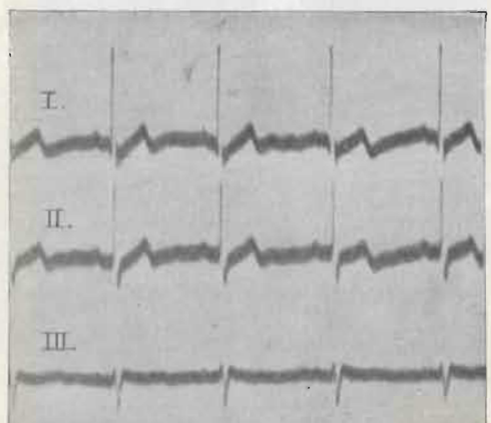
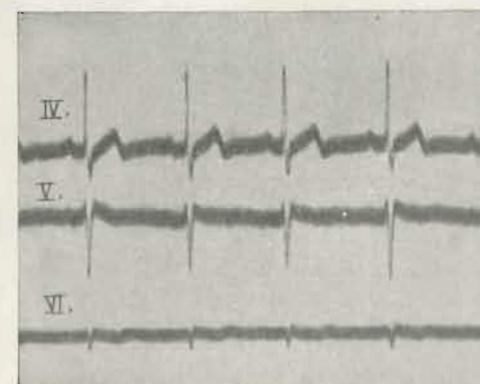


Fig. VII.

IV. Right Arm Right Foot

V. Left Arm Right Foot

VI. Right Foot Left Foot



simultaneously on one strip of paper, all the six possible electro-cardiograms can be recorded on two strips.

To obtain records of the **Pulse** from the wrist, neck, abdomen, etc., the mechanical energy is converted into electrical energy by a microphone. The changes produced in the resistance of this instrument cause changes in the strength of the current, which are recorded by the mirror galvanometer.

The **Sounds of the Heart** are intensified first by resonance, and here again a microphone converts the acoustic waves into electric waves, which are traced down by the pencil of light reflected from the mirror galvanometers on the photographic paper. The relative strength, the time of commencement, and the purity of the sounds can be seen from the records.

No. 4496. **Complete Apparatus,** including the arc lamp, with the necessary resistances, the camera (packing included) is **£155 0 0**

A portable and cheaper apparatus will be ready in August, 1913. Prices and illustrations can be had on application.

Electro-Cardiograph only, without arrangement for making the records of the pulse and the heart sounds **£130 0 0**

If the Apparatus is to be used on an alternating circuit, a motor transformer becomes necessary, to convert the current for the arc lamp into a continuous current, which increases the price by **£27.**

The Apparatus can be seen in working order, and instructions in its use will be given in our Laboratory, 71, New Cavendish Street, W.

Some Illustrations of the curves obtained will be found on the two preceding pages.

We also supply the Electro-Cardiograph of **Einthoven.**

Price complete, about **£230.**

A special pamphlet describing this apparatus can be had on application.

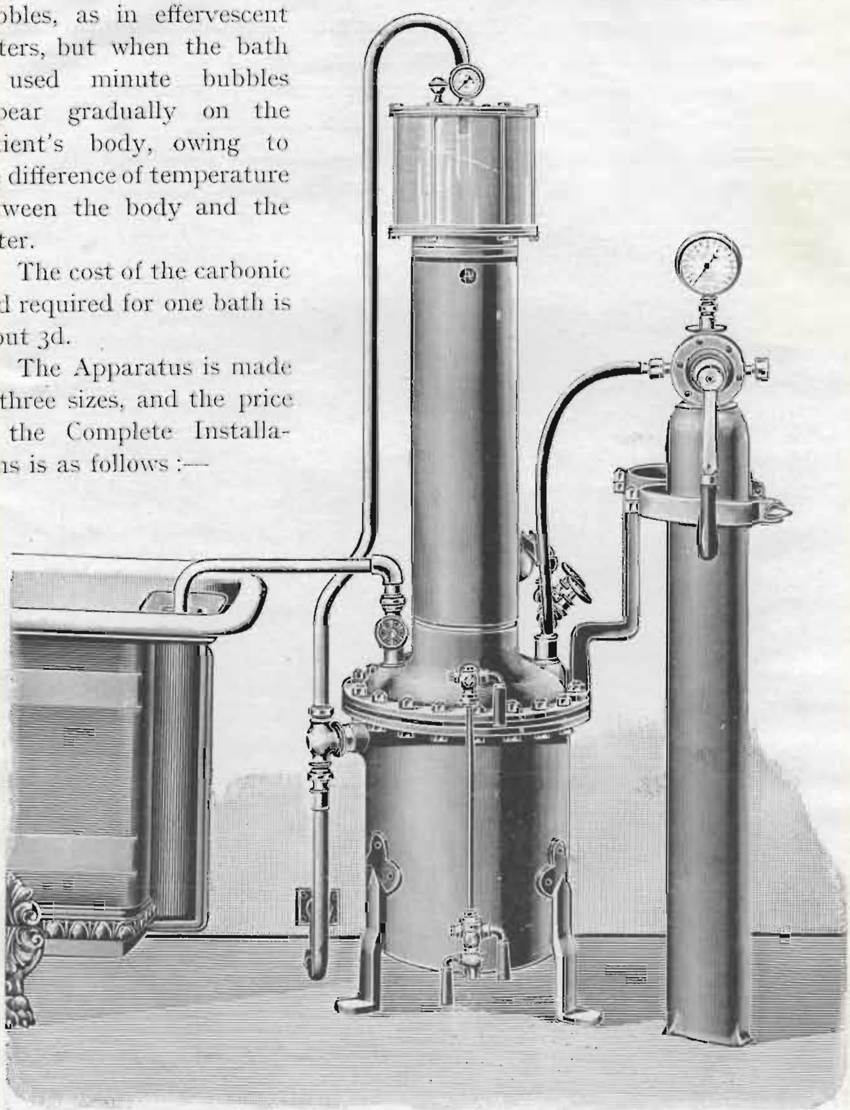
CARBONIC ACID BATHS.

As used at NAUHEIM and other Spas.

The process of mixing the carbonic acid gas with the water is perfect. The air is first extracted from the water, to bring it in a condition that it can absorb a large quantity of carbonic acid. The latter does not escape in visible bubbles, as in effervescent waters, but when the bath is used minute bubbles appear gradually on the patient's body, owing to the difference of temperature between the body and the water.

The cost of the carbonic acid required for one bath is about 3d.

The Apparatus is made in three sizes, and the price of the Complete Installations is as follows :—



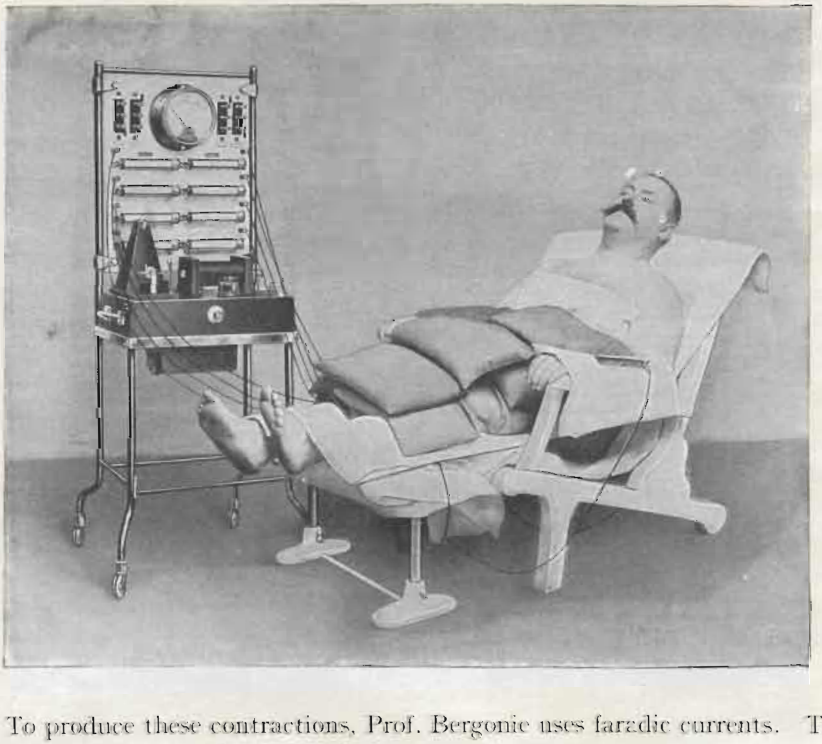
No. 4490.

No. 4490.	**Complete Apparatus,** for private use in the patient's own house	£35	0	0
No. 4492.	**Complete Apparatus,** for hydros	44	0	0
No. 4494.	**Complete Apparatus,** for large spas	52	0	0

APPARATUS FOR TREATING OBESITY BY PROF. BERGONIE'S METHOD.

Obesity can be treated by restricting the diet and by increasing physical exercise. Though these methods are simple and efficient, few patients have the will power to continue such treatment for many months. Physical exercise stimulates the appetite too much in some cases, whilst in others it is impossible on account of heart disease, asthma, arteriosclerosis, gouty affections, etc.

It is therefore of great interest that Prof. Bergonie, of Bordeaux, has shown that by stimulating the muscles in a suitable manner with electric currents, powerful rhythmic contractions can be produced which replace the physical exercise so efficiently that patients lose from 300 to 800 grams in weight per sitting, *without suffering any pain or even discomfort.*



To produce these contractions, Prof. Bergonie uses faradic currents. The coil is wound with a thick wire, so that no more than 10 to 12 volts are obtained. The interrupter gives a frequency of about 60 interruptions per second, and is connected with a condenser, so that sparking is avoided and currents of even strength, free from any jerks, are produced. The strength of the currents used can be measured with a hot wire M.A. meter ; it varies from 20 to 80 M.A., and can be controlled by means of rheostats.

In order to influence all the mucles evenly, the patients are placed undressed on a chair provided with large metal electrodes. Four flexible elec-

trodes are then placed one on the abdomen or chest, one on the upper legs, and one each on the arms. The strength of current in each of these four circuits is adjusted separately, and a metronome interrupts the current rhythmically, 100 to 120 times per minute, so that the current is on about one-fourth of a second and off one-fourth of a second. The muscles contract and relax, and bags filled with sand of a total weight of 50 to 100 kilos, placed on the patient, are raised and lowered 2 to 4 centimeters with each contraction. All the muscles, with the exception of those of the throat and neck, participate in the work.

The skin becomes red and perspiration sets in. The respiration increases only to a very slight extent, but becomes deeper. The rate of the pulse rises, too, but much less than with physical exercise. The blood-pressure rises slightly. Immediately after the application is over, respiration, pulse, and blood-pressure again become normal. The patients feel no pain at all, but can read, chat, or even go to sleep. There is no sensation of fatigue left, but the patients feel brighter and more energetic. The applications should be given daily, once or twice, and the sittings should last fifteen to twenty minutes at the beginning, forty to seventy minutes towards the end of the treatment, which should be continued four to six weeks.

The losses in weight are 400 to 800 grammes per day at the beginning, later on 200 to 500 grammes, i.e., 1½ to 3 kilos per week. The average results obtained were losses of 15 to 18 kilos. It is obvious that better results will be obtained if the patient submits to a suitable diet.

The same apparatus has proved very efficient for treating **chronic constipation** and some heart diseases. The pulse rate can be lowered by the rhythmical interruptions.

The price of the apparatus is as follows :—

No. 4700.—Electric Apparatus to produce and control the faradic currents as described, including hot wire milliampèremeter and metronome, mounted on marble plate and steel trolley, to work off a 100 to 250 volt continuous current	**£50 0 0**
No. 4710.—Chair, with metal electrodes, and *provided with four electric thermophores to keep the metal electrodes warm*	**12 10 0**
No. 4715.—Eight connecting cords 3 yards long each, and five large flexible electrodes	**4 10 0**

ELECTRO-MAGNETS FOR REMOVING IRON, ETC. FROM THE EYE.

No. 4500.

No. 4504.

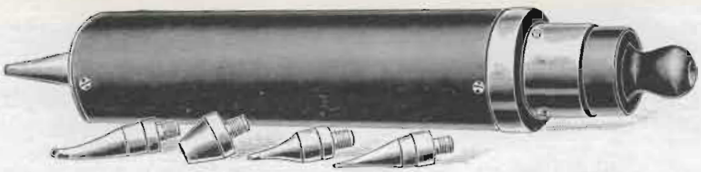
No. 4500. **Small Electro-Magnet,** with five different points, Fig. 4500 .. .. £1 0 0

This magnet is wound for 8 volts, requires a current of 4 ampères, and can carry a weight of about 10 lbs.

No. 4504. **Medium-sized Magnet,** Fig. 4504—

(*a*) Wound for 8 volts and 5 ampères 1 4 0

(*c*) Wound for 200 to 250 volts and 0·2 ampère .. 1 16 0



No. 4506.

No. 4506. **Large Electro-Magnet** (Prof. Hirschberg's), Fig. 4506, with five points—

(*a*) Wound for 8 volts and 7 ampères .. 3 10 0

(*c*) Wound for 220 volts and 0·25 ampère 4 4 0

This size magnet can carry a weight of about 30 lbs.

No. 4512. **Prof. Schloesser's Electro-Magnet.** This powerful magnet is suspended in a fork as shown in Fig. 4512; it is movable in any direction, and can carry a weight of about 40 lbs. with the currents mentioned below—

(*a*) Wound for 12 volts and 15 ampères .. £6 6 0

(*c*) Wound for 220 volts and 1 ampère £8 10 0

No. 4512

This size magnet can carry a weight of about 80 lbs.

No. 4516. **Large Electro-Magnet** on telescopic stand, with a long iron core suspended in a fork, movable in any direction—

Wound for 220 volts and 1 ampère £11 11 0

No. 4516

No. 4520

No. 4520.	**Large Haab's Magnet,** latest type, Fig. 4520— Wound for 220 volts and 8 ampères	**£29 0 0**

The prices include 3 different points. The magnet can carry a weight of over 600 lbs. The current has to be switched on or off with the foot.

We have supplied our Electro-Magnets amongst others to :

The War Office ; the India Office.

King George's Hospital, Lucknow.

Royal Westminster Ophthalmic Hospital ; Central London Ophthalmic Hospital, etc., etc.

Royal Infirmary, Edinburgh ; Royal Infirmary, Dundee ; Dundee Eye Infirmary ; Cardiff Infirmary ; Swansea General and Eye Hospital ; Royal Victoria Hospital, Belfast ; Sunderland and Durham County Eye Infirmary ; Derbyshire Royal Infirmary ; Bolton Infirmary and Dispensary ; Launceston Infirmary and Rowe Dispensary ; Dunedin Hospital ; New Royal Naval Hospital, Chatham ; Grimsby and District Hospital, etc., etc.

J. R. Rolston, E. J. Fox, Randle Leigh, W. H. De Silva, Ceylon, etc., etc.

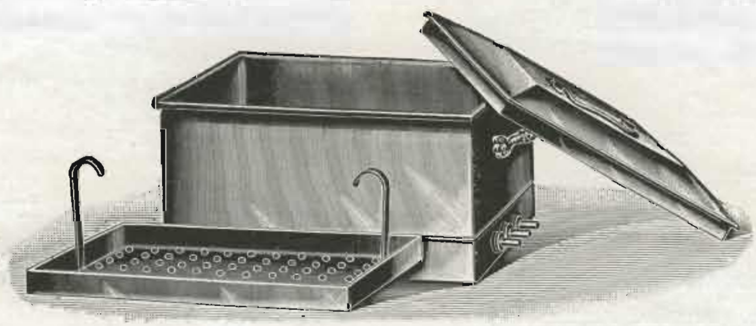
No. 4600.	**Invalid's Bell,** Fig. 4600, with 12 yards of flexible silk cord, pear push, and dry cells	**£0 15 0**
No. 4650.	**Cylinder,** to heat water or other liquids in a glass, jar, or kettle, Fig. 4650..	**0 12 6**

This cylinder has to be immersed in the liquid which is to be heated. It is very convenient for dentists, surgeons, etc., for raising quickly the temperature of a glass of water. The cylinders are practically indestructible, but *must not be connected with the supply before they have been inserted in the liquid.*

No. 4600.

No. 4650.

No. 4654. **Electric Sterilising Apparatus,** Fig. 4654, in rectangular form, size 8 in. long, 4 in. wide, $2\frac{3}{4}$ in. deep; 4 ampères **£2 10 0**



No. 4654.

No. 4656. Similar Apparatus, 12 in. long, 8 in. wide, 5 in. deep; 8 ampères **5 5 0**

No. 4658. Similar Apparatus, 20 in. long, 8 in. wide, 5 in. deep; 12 ampères **6 5 0**

No. 4660. **Water Kettles**, nickel plated, with cables :—

A Capacity, $\frac{1}{2}$ pint	.. ..	**0 17 0**
B Capacity, 1 pint..	. . .. .	**1 3 6**
C Capacity, 2 pints	.. ..	**1 8 6**

No. 4663. **Water Jugs**, nickel plated outside, enamelled inside, with cables :—

A Capacity, 1 pint	.. ..	**1 16 0**
B Capacity, 2 pints	.. ..	**2 3 0**
C Capacity, 3 pints		**2 12 0**

No. 4660.

No. 4663.

No. 4666.

No. 4666. **Water Jugs**, nickel, with cables :—

A Capacity, 2 pints	**£1 14 0**
B Capacity, 3½ pints	**1 19 0**
Antique Copper, with cables :—	
D Capacity, 2 pints	**1 19 0**
E Capacity, 3½ pints	**2 6 6**

TERMS FOR LENDING OUT BATTERIES.

The more frequently-used batteries and instruments can be had on hire on the following conditions :—

If you desire an apparatus on hire, you must mention this clearly when sending the order. When you have finished with it, return it carefully packed, or, if in London, send us notice that we may send for it.

Carriage both ways has to be paid by the customer. *Patients and Nurses are requested to pay half the value of the battery as a deposit.* This money, less the hire, will be repaid when the battery is returned.

If you desire to hire a battery with the option of purchasing it, a *new* instrument will be sent, but the price charged per month will be higher than the prices mentioned below. If you decide to keep it, the amount paid for hire will be deducted from the price of the instrument.

Freshly-charged batteries for Galvanisation, Electrolysis and Faradisation, are lent out for one month or longer. The terms depend on the value of the battery, number of cells and accessories, and vary between 10s. 6d. and 30s. per month.

Batteries and Instruments for Electric Light, and Galvanic Cautery, are lent out at the rate of 10s. 6d. per week, or less ; £1 5s. for a month. For destroyed lamps and platinum burners there will be an extra charge.

In returning batteries, *please put name and address of sender inside* the battery, to avoid mistakes.

TERMS.

Guarantee.—We guarantee our Apparatus for **one year**; i.e., should any defect due to imperfect material or workmanship be discovered within one year from time of delivery, we undertake to make it good free of charge.

Not included in this guarantee are goods which deteriorate even with fair wear and tear, such as cells, lamps, focus tubes, cords, etc.

As references, we have given the names of many well-known members of the medical profession and hospitals using the more elaborate of our apparatus.

The prices mentioned in this Catalogue are subject to 5 per cent discount for cash with order, or on delivery; the prices are net afterwards, and 5 per cent per annum interest is charged on all accounts not settled within six months after delivery.

In ordering, please mention the list number of the apparatus to avoid mistakes. *Detailed printed directions for use are sent with each instrument.*

Orders from abroad from unknown customers will be executed only if a remittance covering at least 25 per cent of the value of the goods is sent with the order. The remainder has to be paid on delivery.

Packing is most carefully carried out, and charged at cost price. If the cases, including packing material, are returned in good condition, carriage paid, half the amount charged for packing will be credited. The delivery is at cost and risk of consignee. All the frequently used apparatus are kept in stock, others can be supplied within a reasonable time.

The woodcuts are made from photographs taken from the instruments, but we cannot guarantee every detail to remain as the illustrations show them now. Additional lists of newly constructed apparatus are issued from time to time.

Electro-medical apparatus of every description are promptly repaired. In returning batteries for re-charging or repair, *please put name and address of sender inside* the battery to avoid delays and mistakes.

Second-hand apparatus can occasionally be obtained at considerably reduced prices.

Hospitals and other charitable institutions can obtain special prices on application.

Competent assistants can be sent at moderate charges to any part of the country to erect the apparatus and instruct the owners in their management.

ALPHABETICAL LIST OF THE CONTENTS OF THE PRICE LIST.

2748.13 JOHN WRIGHT AND SONS LTD., PRINTERS, BRISTOL.


71 SCHALL & SON
SCHALL & SON 75
75 SCHALL & SON


New Cavendish Str
Manchester
Square
Langham Pl.
Cavendish
Square
Regent
Oxford Street